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The Impact of AIDS Treatment on Savings and Human Capital Investment in Malawi

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Keywords
Life Expectancy, Human Capital Investment, Savings, HIV/AIDS, Malawi

Disciplines
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Abstract

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JEL Classification Codes: O12, I15, J24
Keywords: Life Expectancy, Human Capital Investment, Savings, HIV/AIDS

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1 Introduction

The AIDS epidemic has dramatically decreased life expectancy in sub-Saharan Africa (SSA). In southern Africa, the region hardest-hit by the epidemic, life expectancy has fallen by nearly 25 percent in the past 15 years (UN Population Division 2012). The recent widespread availability of antiretroviral therapy (ART), a drug treatment that drastically slows the progression of AIDS, is reversing this trend. As a result, adult life expectancy has started to increase again in many SSA countries (Bor et al. 2013; Floyd et al. 2012).

This paper uses the expansion of AIDS treatment in Malawi to study the impact of sudden life expectancy gains on savings and investment in human capital.[1] A longer life expectancy encourages human capital investment by increasing the time horizon over which the investment pays out (Ben-Porath 1967; Becker and Tomes 1979). Additionally, changes in life expectancy are likely to affect savings decisions. Individuals may save more if they expect a longer retirement, but may, in fact, save less if they expect a longer and healthier working life (Bloom et al. 2003; Fogel 1994, 1997). If individuals accumulate savings as a form of insurance against the illness and death, we might expect savings to decline. Alternatively, if individuals accumulate savings for investment purposes due to credit constraints, savings might increase as long-term investments become more attractive. Since the relationship between life expectancy and savings is theoretically ambiguous, it is ultimately an empirical question and one that few studies have explored causally.[2]

[1]ART increases life expectancy by reducing the mortality risk from engaging in risky sexual behavior: it reduces both the likelihood of death conditional on infection and the transmission probability. However, the effect of ART on life expectancy is mediated through the behavioral response, since individuals may increase risky sexual behavior (Lakdawalla et al. 2006; Wilson et al. 2011; De Walque et al. 2010; Oster 2012; Friedman 2012). In South Africa, recent evaluation of demographic surveillance data has shown that objective life expectancy has increased as a result of ART and HIV incidence has declined, suggesting that even if individuals respond by increasing risky sexual behavior, the response does not overwhelm the benefits of ART (Bor et al. 2013; Tanser et al. 2013).

[2]Many studies have looked at the effect of longevity on savings in cross-country analyses, generally finding a positive correlation (Lee et al. 2000; Bloom et al. 2003; Zhang and Zhang 2005). Some studies have looked at the effect of HIV on savings in cross-country regressions, but no consensus has yet emerged (Bonnel 2000, Lammers et al. 2007). To our knowledge, only one other study attempts to identify the causal relationship between life expectancy

Using longitudinal survey data, we estimate the impact of ART availability on savings, expenditures on children's human capital, and children's schooling. Our identification relies on spatial variation in ART availability as measured by the respondents' distance to the ART facility. By combining precise GPS locations of households with administrative records on locations and start-of-ART-service dates for clinics, we calculate the respondents' exact distance by road to their nearest ART facility. We employ a difference-in-difference strategy with individual fixed effects, comparing outcomes before and after ART became available at the facility along the distance gradient.

Malawi was severely affected by the AIDS epidemic, with a national prevalence that peaked at 15 percent in 1997. In 2003, through support of large international donors and governments, the Malawian government started to make ART available for free, and the ART program has been expanding rapidly since. The scale-up of the program, widely regarded as a public health success, has resulted in measured declines in adult mortality (Jahn et al. 2008; Floyd et al. 2012).[3] And while HIV-positive persons gain the most from treatment becoming available, HIV-negative individuals also face large gains in life expectancy through reductions in future risk.

We are able estimate the effect of ART availability among the HIV-negative respondents and over a short time horizon, thereby minimizing concerns of estimating the direct health effects of treatment, population shifts, and other general equilibrium effects. Additionally, the data contain information on self-reported mortality risk, allowing for a unique analysis linking changes in outcomes to changes in subjective expectations. Since subjective expectations are the determining factor in decision-making, measuring subjective probabilities

and savings. Thornton (2012) finds that learning one's HIV status had only short term effects on subjective beliefs about ones HIV status, and no apparent effects on savings, expenditures, employment, and long-term subjective beliefs. Individuals who learn they are HIV-negative continue to worry about becoming infected in the future. Godlonton and Thornton (2013) suggest this might be an important factor, finding that village-level testing is more important for HIV beliefs and behavior.

[3]This effect of ART on mortality has not remained unnoticed by the local populations. For example, coffin sales declined, funerals became less common, and improvements in the health and economic activities of HIV-positive persons receiving ART have been widely recognized (Mwagomba et al. 2010; Ashforth and Watkins 2013; Thirumurthy et al. 2012b).

provides a direct test of the theory (Manski 2004).

The ART rollout in Malawi provides a good setting to study the effect of life expectancy on investment and related life-cycle behaviors for a number of reasons. UN-based estimates of life expectancy gains from eliminating AIDS mortality in Malawi are 12.7 years. Thus, the life expectancy gains are large and occur primarily as a result of changing *adult* mortality risk.[4] HIV/AIDS affects individuals after major human capital investments have been made but before they have retired from the labor market. Moreover, the positive shock from eliminating mortality risk from AIDS provides a cleaner experiment than the negative shock from the arrival of HIV, because the negative shock is necessarily accompanied by death, which has large and immediate direct consequences for survivors. Finally, the shock to life expectancy is both long-term and impacts the general population. Thus, it is more informative about the effect of life expectancy on human and physical capital accumulation in the macroeconomy as a whole, which is the mechanism typically studied in growth theory (Solow 1956; Koopmans 1965; Romer 1986).[5]

We find a strong response in savings behavior: halving the distance between a respondent and the ART facility—a reduction of approximately 5 kilometers for the average respondent—results in an increase in the propensity to report any savings by 10 percentage points. Additionally, we find that ART availability increases investment in human capital. Reducing the distance by half increases expenditures on children's education by US$3.08 and children's medical spending by US$0.68 per child (combined, an increase of 3% of annual

[4]We emphasize that the life expectancy gains result from changing adult mortality risk, as distinct from infant or old-age mortality. The latter should not impact investment decisions through the mechanism we are trying to identify. Many previous studies using cross-country regressions consider how life expectancy impacts education and growth (Acemoglu and Johnson 2007; Lorentzen et al. 2008; Bloom et al. 2009; Hansen 2013); however, they rely on life expectancy gains resulting primarily from reductions in infant mortality.

[5]Oster et al. (2012) estimate the causal impact of limited life expectancy on human capital investment using genetic variation in the population of Huntington disease patients. The study provides a well-identified estimate of the elasticity of demand for education with respect to years of life expectancy in the context of Huntington disease (HD) patients. Due to the emphasis on the difference between HD patients' life expectancy and that of the population, the results may not extend easily to developing countries.

reported earnings spent on each child). We also observe substantial gains in educational attainment for children of the respondents near ART. Halving the distance to ART implies an increase in schooling by 0.3 years.

The identifying assumption for our analysis is that individuals living near and far from ART facilities would have similar trends in absence of ART. Using pre-period data, we show that trends in outcomes and other characteristics are not correlated with proximity to the ART facility. The results are robust to including controls for spatial and demographic characteristics, reported economic shocks, and participation in other government aid programs. While we find that ART availability increases savings and investment behavior, we do not observe changes in reported earnings, suggesting that the results are not driven by income shocks. The magnitudes are also similar and remain significant among HIV-negative respondents, indicating that the results are not driven by the direct effect of respondents receiving life-saving medication. And while it is a-priori plausible that mechanisms such as a reduced morbidity of HIV-positive persons receiving ART lead to reduced care-taking responsibilities for HIV-negative persons, our results indicate that mechanisms such as household caretaking burdens from AIDS related illness, death, and orphanhood, do not explain our findings of the effect of ART availability on investment.[6]

We find that ART availability measurably decreases self-reported mortality risk. We calculate the implied change in *subjective* life expectancy based on the impact of ART proximity on perceived mortality risk. The estimates suggest that respondents' perceptions about mortality reduction are roughly in line with UN-based estimates: reducing distance to an ART facility by 5 kilometers increases subjective life expectancy by 6.8 years. Taken together, these findings suggest that individuals actively adjust their investment decisions in response to a subjective lengthening of their investment horizon.

[6] Our approach is unable to rule out other general equilibrium effects of ART that may impact investment. However, the effects of changes in risky sexual behavior, fertility, wages, and demand are likely to take time to become apparent in this setting. The very short time frame during which we observe the response to ART mitigates concern that our estimates are capturing these other spillovers.

Last, we calculate the marginal effect of life expectancy on schooling. The increases in educational attainment reported above reflect changes in life expectancy for both parents and children. Therefore, to isolate the effect of an additional year of a child's life expectancy, we exploit the differential change in life expectancy by gender. Higher HIV prevalence rates and younger ages of infection imply that women gain 3.3 more years in life expectancy from eliminating AIDS mortality than men (UN-based estimates). In a triple-difference approach, our estimates of the additional gain in schooling by gender imply that one additional year of life expectancy increases schooling by 0.1 years.

This study contributes to the literature by investigating the consequences of expanded ART availability on life cycle dynamics in the general population. The benefits of ART availability are not necessarily restricted to HIV-positive individuals. For example, HIV-negative persons face future risks of HIV infection, the consequences of which are reduced by ART. Previous studies on ART have focused on the direct effect of treatment on HIV-positive persons (Thirumurthy et al. 2012a,b), or the effect of ART on risky sexual behavior (Lakdawalla et al. 2006). However, very few studies exist that have evaluated the potential benefits of ART expansion as incurred by the general population.

Our human capital results add to a growing literature on the impacts of life expectancy on human capital (Jayachandran and Lleras-Muney 2009; Fortson 2011; Oster 2012). Our findings are consistent with that literature. Furthermore, the observed changes in subjective life expectancy allow us to be more confident in the mechanisms driving the results.[7]

[7] Economists rarely measure subjective expectations and must rely on actual population shifts in adult mortality to identify the effect. For example, Jayachandran and Lleras-Muney (2009) find that the reduction in maternal mortality in Sri Lanka during the mid-20th century substantially improved female education outcomes. Fortson (2011) exploits geographic and time variation in HIV prevalence in Sub-Saharan Africa to estimate the effect of the HIV/AIDS epidemic on human capital investment. While these studies provide evidence in support of the standard model of human capital accumulation, neither provide direct evidence of the mechanism. Moreover, empirical strategies in macro-based studies over long time horizons must rely on changes in life expectancy that affect population dynamics and are likely to influence decisions in ways that are not related to changes in expectations (Santaeulalia-Llopis 2008; Ardington et al. 2012). For example, one important consequence of changes in mortality is the immediate effect on family structure. After a death of an adult, the dependency ratio in that household increases.

Our savings results provide another channel through which life expectancy may impact growth. Standard models of economic growth include savings as a driver of growth, although the impact of life expectancy on this behavior is theoretically ambiguous. Our evidence suggests that, higher life expectancy does prompt more savings. The impact of life expectancy on growth is therefore greater, even, than would be suggested by the human capital channel alone.

2 Context

Malawi is one of the countries hit hardest by the AIDS epidemic, with nearly one million people currently living with HIV/AIDS, and it is one of the world's poorest countries with a GDP per capita of $340 (PPP adjusted $918). Adult HIV prevalence peaked at 14.7 percent in 1998 and has steadily declined since (UNAIDS 2010). The current HIV prevalence, at 11 percent, is still one of the highest in Africa (2010 Malawi DHS). Malawi's population, 15.4 million, is over 80 percent rural and supports itself primarily through subsistence agriculture.

The educational attainment in Malawi is low. The mean years of schooling is 4.2 for adults over 25; and net secondary school enrollment, at 24%, is very low (WDI 2010). Qualitative interviews suggests that risk perceptions about HIV/AIDS factor into parental decisions about their children's education (Grant 2008). Primary education goes up to grade eight and is not compulsory. The official starting age is six years old; but, it is not uncommon for children to start considerably later. While the government established free primary education in 1994, which increased attendance rate by approximately 50% (Kadzamira and Rose 2003), families are still responsible for uniforms and school supplies and must consider the opportunity cost of enrollment as children often participate in wage labor or help with household chores.[8]

Life expectancy at birth in Malawi is 54 years, and AIDS is the main cause of adult mortality (AVERT 2012). In direct response to the previous governments' refusal to acknowledge the epidemic, in 2003 the Malawian government

[8]In 1999, the ILO estimated that 32.2 percent of children between the ages of 10 and 14 in Malawi were working. Children work in the agricultural sector, often alongside their parents on commercial farms and frequently perform domestic work to allow adults to work longer hours in the fields (US Department of Labor 2002).

announced it would provide free antiretroviral therapy to HIV patients. The ART program was paid for largely by the Global Fund, which contributed a total of US$294 million. The HIV Unit in the Ministry of Health (MOH) has been responsible for the dissemination of the medication, the training of nurses and doctors, and other logistics associated with the rollout. The MOH maintains detailed records of the rollout, and performs site checks at all ART facilities on a quarterly basis. Other notable features of the rollout include its systematic and well-monitored expansion, the use of existing clinics and hospitals as the primary mode of expansion, and a short time frame between when clinics were selected to provide ART and when they actually began providing the medication.

The Ministry of Health (MOH) began providing free ART in June 2004 at nine clinics. By the end of 2010, the number of clinics providing ART had grown to nearly 300 with over 350,000 patients ever initiated on ART, and 211,000 receiving treatment in 2010.[9] The rollout occurred in two stages: Round 1 (2004-05) had the most rigorous requirements for clinics, and 60 sites (mostly hospitals and large clinics) were chosen to begin providing ART. In 2006, the government outlined a 5-year plan to expand its ART program with the goal of attaining 100% coverage of those in need by 2010. To that end, the MOH aimed to maximize geographical coverage and relaxed the standards for facilities, considering all clinics with at least one clinician and one data clerk. Although clinics that provide ART are generally bigger and better equipped than those that do not, the differences are substantially smaller for sites that began providing in later stages of the rollout (Appendix Table E.2).

ART patients are required to visit the clinic every two weeks to receive medication in the first month after initiation, then every month for the next six months, and every three months thereafter. Limited transportation in-

[9]By June 30, 2010, there were 396 clinics (290 static and 106 outreach) in the public and private sector that had registered a total of 359,771 patients on ART. Although private clinics also receive the ART medication at no cost from the MOH, they are permitted to charge patients a small fee. The private sector accounts for a very small part of the ART rollout, and less than 4% of patients were ever initiated on ART through the private sector (MOH 2011 Quarterly Report).

frastructure, a poor road network, high fuel prices, and nonexistent public transportation make it difficult for individuals with HIV, particularly those who are sick enough to be eligible,[10] to travel long distances to receive treatment.[11] Anecdotal evidence from clinic visits suggests that most ART patients lost to followup are those living far from clinics. Distance to the health facility is used by health planners to define access to health services, and a number of recent studies from Sub-Saharan Africa have found that geographic distance to a health facility is an important factor in child mortality (Okwaraji et al. 2012; Okwaraji and Edmond 2012; Guenther et al. 2012; Schoeps et al. 2011).

3 Estimation

3.1 Data

This paper uses data from the Malawi Longitudinal Study of Families and Health (MLSFH), which is an ongoing panel survey that has been conducted since 1998 (Kohler et al. 2014).[12] The MLSFH collected GPS coordinates for sampled households and performed HIV testing in 2004, 2006, and 2008. The survey is conducted in three distinctive districts of Malawi: Rumphi in the north, Mchinji in the center, and Balaka in the south. The sample is entirely rural and not necessarily meant to be nationally representative, although key characteristics are similar to those found in the Demographic and Health Survey (DHS). Attrition in the MLSFH is high: approximately 25 percent of

[10] The guidelines for treatment eligibility were determined by the Ministry of Health based on WHO recommendations. As there are only a few CD4 machines in Malawi, eligibility is determined solely by clinical symptoms of Stage 3 (advanced) or 4 (severe) AIDS. The WHO later revised the recommendation to include individuals with higher CD4 counts. The MOH released new guidelines in 2011 that reflected the WHO revisions; however, this change is not pertinent to our analysis.

[11] Transportation infrastructure is generally poor. Only primary roads are paved; secondary and tertiary roads are normally dirt roads and become muddy and difficult to navigate during the rainy season. Few people own cars or motorcycles. The most common modes of transportation are walking, biking, hiring a bike taxi, and hitchhiking (though it is customary to pay the driver).

[12] This survey has also been referred to as the Malawi Diffusional and Ideational Change Project (MDICP) in the past. With major data collection rounds in 1998, 2001, 2004, 2006, 2008, 2010, and 2012 for up to 4,000 individuals, as well as ancillary surveys and qualitative studies, the MLSFH has been a widely-used dataset for research on health, family dynamics, social networks, and HIV infection risks in a rural SSA context (Kohler et al. 2014).

the 2006 sample is lost to follow-up by 2010. However, this attrition is not correlated with ART proximity.[13]

The main analysis uses survey rounds from 2004, 2006, 2008, and 2010 (however, some outcome variables were not available in the 2004 round). ART became available at clinics within the MLSFH study regions shortly before the 2008 survey.[14] The data from the 2004 round allow us to test for differential pre-ART changes for variables that are available in all four rounds.

We use distance to the nearest ART facility, a measure of access, as the source of identifying variation. Using GPS data on the locations of respondents and clinics, we calculate the distance to the nearest facility providing ART at the time of the survey. To ensure that the most relevant information is captured, we calculate the distance to a nearest facility by road.[15] We also calculate the distance to the nearest clinic (regardless of ART status), market, school, and major road.[16] These variables serve as important controls, as distance to one location is correlated with other spatial features that may pose a threat to identification. Figure 1 shows a map of these features and the survey area of sampled households in the Mchinji district.

Before 2007, the nearest ART facility for most respondents was more than 25 kilometers away (the median distance was 27 kilometers), rendering ART virtually inaccessible for the population in the rural MLSFH study region. By 2008, ART arrived to at least one clinic within the survey area of each region, and the median distance to the nearest ART facility became 8.9 kilometers. All respondents are at least a kilometer away from ART, which makes it unlikely that we are picking up effects from higher foot traffic near the clinics. Several clinics also began providing ART after the 2008 survey in the sam-

[13]Attrition is comparable to that of other longitudinal datasets in developing countries (Alderman et al. 2001). See Kohler et al. 2014 and Anglewicz et al. 2009 for a detailed summary of the data and attrition in the MLSFH.

[14]ART was available at the clinics for an average of 7 months prior to the 2008 interviews.

[15]Data on road networks were provided by the National Statistics Office of Malawi. The correlation between straight-line and by-road distance was 0.9 and the results are robust to using straight-line distance (not shown).

[16]We use estimated population density at a resolution of 100 meters from the Afripop database as an additional control.

ple regions. These clinics were generally farther away from the respondents than existing ART facilities. In the analysis, we use the 2008 distance to ART facility interacted with year as the identifying variation. Figure 2 shows the distribution of distances to respondents' nearest ART facility in 2008.[17] The distribution of distances is not uniform and differs by region (see densities by region in Appendix Figure E.1). At any given distance to ART, the regions are not equally represented. To ensure we capture the relevant variation over time, we include region-by-year controls throughout the analysis.

Respondents knew about the existence of ART well before it became available in their area. By 2006, 95 percent of respondents had heard of ART, and had relatively accurate perceptions of the effect of ART on mortality of HIV+ persons. And even in 2004, over half of the respondents reported knowing someone on treatment. This suggests that our findings are driven by individuals responding to access, as opposed to learning about the new technology.

Table 1 provides summary statistics of the data being used from survey year 2006, before treatment became available ("pre-ART"). Panel A describes the demographic and economic characteristics of the sample, and Panel B describes HIV and risk perceptions.[18] In addition to the standard battery of questions in a household survey, beginning 2006 the MLSFH includes a module on subjective expectations, which elicits respondents' beliefs about probabilities using the bean method (Delavande and Kohler 2009). Individuals are asked to choose the number of beans (0 to 10) that reflects the probability of an event occurring. Among other things, respondents were asked to assess their own mortality risk over a 5-year horizon. Panel B provides summary statistics for the respondents' own 5-year mortality risk, perceived own-HIV risk, perceived HIV prevalence, and whether respondents report being worried about AIDS.[19] These measures allow us to explicitly link changes in economic

[17]The distance to the nearest ART facility changed for only 30 respondents 2010. Figure E.2 plots the distribution of distances to the nearest facility by year, showing little difference between 2008 and 2010. The results are unchanged if we use time-varying ART proximity instead of the 2008 distances.

[18]We report all monetary values in USD using the 2010 exchange rate of 150 MWK = 1 USD.

[19]We provide two measures of the respondents' perceived HIV risk. One is the perceived

behavior to measured changes in subjective expectations. We use the 5-year subjective mortality risk to calculate the implied effect of ART on subjective life expectancy.

Table 1 Panel C summarizes pre-ART savings and expenditure outcomes of interest for our analysis. Respondents were asked to report the total amount of money they have in savings (such as a bank account, savings group, or cash).[20] Additionally, respondents reported expenditures on their children's education, medical services, and clothing in the past three months. Panel D of Table 1 shows summary statistics for the sample of children of the respondents who are linked over time using data from the household rosters.[21] The main outcome for children used in our analysis is grade completion.[22] Panel E reports statistics of spatial characteristics.

3.2 Empirical Strategy

We estimate the effect of ART availability on savings, child expenditures, and schooling outcomes. Using a difference-in-difference strategy, we compare outcomes of respondents living near an ART facility to those living far, before and after ART became available. Distance to the nearest facility proxies for ART availability, incorporating both travel cost and information. The main regression analysis is based on the following specification:

$$y_{ijrt} = \beta Post_t \times Proximity_{ijr} + \alpha_{ijr} + \delta_{rt} + \varepsilon_{ijrt} \tag{3.1}$$

where y_{ijrt} is the outcome for respondent i in village j, and region r, and time period t. $Post_t$ is an indicator for years 2008 and 2010 of the survey, i.e., the years after which ART became available in the MLSFH study regions.[23] $Proximity_{ijr}$ is the proximity to the nearest ART facility in 2008 and is time-invariant. The baseline specification also includes individual-level fixed effects,

risk using the bean method, and the second is the likelihood of HIV infection using the Likert scale (0=no likelihood, 1=low, 2=medium, 3=high likelihood).

[20] Fewer than 5% of respondents belong to savings groups.

[21] See Castro et al. (forthcoming) for a detailed explanation of the linkage process.

[22] We also report statistics on the child's subjective health score reported by the parent (1= poor health, 5 = excellent health).

[23] In all specifications, we allow for separate indicators for 2008 and 2010.

α_{ijr}, which absorb the time invariant proximity variable, and region-by-year fixed effects, δ_{rt}, which absorb the indicator for the post period. Standard errors are clustered by village and are robust to heteroskedasticity.

We parametrize ART proximity as the negative of log-distance. This parametrization allows for a convenient interpretation of the coefficient as the effect on the outcome for an individual if the distance to an ART facility were reduced by half.[24] This corresponds to a decrease in distance of 5.68 kilometers from the mean (and median) distance of 9 kilometers. The results are robust to other specifications of functional forms on distance, and we also show the results nonparametrically (see Appendix Figure E.4).

The effect of ART is estimated through the differential change in outcomes along the distance gradient. Distance serves as a proxy for access to ART. It determines the time and monetary cost of getting treatment.[25] While we do not have data on ART uptake over time, we collected data on ART uptake among a subsample of respondents interviewed in 2012.[26] Of the HIV-positive respondents, we find that individuals on ART are 3.5 kilometers closer to an ART facility than those not on ART ($p = 0.07$, $n = 23$). Although the sample size is small, these results suggest that distance plays a role in access to treatment. Additionally, distance facilitates the spread of information about ART availability at a particular clinic.[27] This second aspect may be more important

[24]This interpretation of the semi-elasticity is only accurate for small changes in distance. The precise interpretation of the coefficient is the impact of reducing distance by a factor of e, that is when $ln(\frac{d_1}{d_2}) = 1$, which means that distance must be reduced by more than half. Precisely, this corresponds to a decrease in distance from the mean (9 km) by 5.68 km.

[25]For example, in 2004, as part of an experiment used in Thornton (2008), participants of the MLSFH were offered monetary incentives to obtain their HIV test results at temporary Voluntary Counseling and Testing centers (VCTs). The location of the VCTs was randomized based on the straight-line distance from respondents' households. Voucher amounts, randomized by letting each respondent draw a token out of a bag indicating the monetary amount, were redeemable two to four months after sample collection. Thornton (2008) finds that distance is an important factor in determining whether individuals obtained their results; individuals who lived within one kilometer of the VCT were more than twice as likely to get their results as those who lived between 3 and 4 kilometers away.

[26]This sample included individuals over 45 years old, approximately 1000 respondents.

[27]Oster and Millet (2011) demonstrate that distance to a call center in India is an important factor in the spread of information about requirements to obtain employment. Notably, they find that the spread of information is highly localized and that the information did not

for individuals who are HIV-negative as they are less likely to actively seek information about treatment options.

Our primary identification assumption is that distance to ART is not correlated with unobserved characteristics of respondents that affect trends in outcomes. One way our results arise spuriously is if people near ART are systematically different from those who are far and would exhibit different trends in outcomes regardless of ART becoming available. For example, respondents near health facilities may become more optimistic over time because they have easier access to healthcare, or respondents near the major roads or trading centers may earn more because they have better economic opportunities. While we cannot test the unobservables directly, our dataset contains a rich set of observed characteristics. Thus, we are able to test if these characteristics are balanced along the distance gradient in the pre-ART period.

Table 1, column 3 reports the coefficient on ART proximity, parameterized as the negative log of distance, when regressing each characteristic on ART proximity (controlling for region dummies). The coefficients, which pertain to the pre-ART period (2006), can be interpreted as the expected change (non-causal) in that characteristic as we move 5.68 kilometers closer to the ART. In column 3, Panel E, we note that ART proximity is correlated strongly with other spatial characteristics. For example, moving 5.68 km closer to ART means that individuals are 3.72 km closer to a major market. There are some other patterns. In particular, respondents near ART do *not* exhibit more savings and investment behavior, our outcomes of interest, in the pre-ART period. They are more likely to have a metal roof, and labor income is higher near ART (significant at 10 percent), though other wealth characteristics are not significantly correlated. Additionally, respondents near ART appear to have higher perceived HIV risk and mortality risk, and lower mental health scores. On the other hand, actual infection risk and physical health scores do not vary significantly with ART proximity, and individuals are not significantly more likely to know someone on ART. Parents report that their children are less likely to be in excellent health near ART. Overall, the pre-ART associations in

spread to individuals living more than 5–6 kilometers away from the centers.

Table 1 indicate that individuals near ART do not appear to be systematically different based on background characteristics before ART became available.

Column 4 of Table 1 shows the coefficients on ART proximity after controlling for spatial characteristics and population density. The sample achieves better balance along the distance gradient with the spatial controls, suggesting that many of the differences found column 3 were attributable to the correlation in spatial characteristics and not inherent to the distance to the ART facility, per se. We note, however, that a few pre-ART characteristics remain unbalanced: respondents near ART still reported a higher perceived HIV risk (using the bean method, though not using the Likert scale). Households near ART are still more likely to have a metal roof (though the coefficient is significant only at 10 percent) and are more likely to have a mobile phone.

All of our subsequent results are robust to including controls for spatial characteristics, where the effect of ART is estimated using a comparison group that is equidistance to (non-ART) medical facilities, schools, major roads and markets.[28] Additionally, our results are not spuriously driven by initial demographic differences: we include pre-period levels of characteristics interacted with $Post_t$ to account for compositional differences by ART proximity, and allow for differential trends among these demographic groups.[29]

The identification assumption behind our difference-in-difference estimation is that the sample is balanced in trends, not levels, along the distance gradient. Table 2 tests for differential pre-ART changes for variables that are available in 2004: Panel A reports pre-trends for the demographic and economic characteristics, Panel B reports trends for HIV and risk perceptions, and Panel C shows pre-trends in child expenditures, the outcome of interest.

[28] Specifically, we control for proximity (interacted with $Post_t$) to a primary road, any clinic (regardless of the availability of ART services at the clinic), major trading center, school, and population density. Proximity is parameterized as the negative log of distance. Moreover, the point estimate on $Post_t \times Clinic\,Proximity_i$, where $Clinic\,Proximity_i$ is the distance to any clinic (regardless of ART), shows the effect of being near any medical facility and provides a useful placebo test.

[29] In particular, we also include dummies for roof structure and if the respondent had a mobile phone in the pre-ART period, since these were correlated with ART proximity even after controlling for spatial characteristics.

The table shows no evidence of differential pre-trends in outcomes by distance to ART, with or without additional spatial controls (columns 3 and 4). The lack of significantly correlated changes in other economic variables, HIV status, or risk perceptions suggests that the identification assumption is valid.[30]

Another potential threat to identification is that areas near ART facilities may have different unobserved shocks due to their spatial proximity to landmarks that may also impact individual outcomes. For this reason, we also include controls for reported economic shocks by household, though these are not correlated with ART availability.[31] Another concern is that proximity to ART may be correlated with the provision of other government aid programs such as subsidized maize or other health initiatives.[32] Respondents report their participation for a number of programs, and we find that participation in other aid programs is not correlated with ART proximity. Nevertheless, we include

[30]Individuals near ART were more likely to acquire a mobile phone prior to ART coming online, and in 2006, families near ART were more likely to have a mobile phone. This is a potential threat to identification, since mobile phone uptake may be a proxy for forward-looking behavior (or individuals who had mobile phones early were more likely to take up new technology). Alternatively, families with mobile phones may have an advantage in farming or selling goods at the market. We control for if the respondent had a mobile phone in the pre-period in the regressions to ensure the results are not driven by this group. The results are similar if we control for the *change* in mobile phone between 2004 and 2006 interacted with year (not shown). However, this is not surprising since almost no one had mobile phones in 2004 (0.5%), so the change between 2004 and 2006 behaves identically to the levels in 2006. However, in 2006, very few respondents had mobile phones–only 3.5 percent. By 2008, that number grew to 24 percent and by 2010 to 41 percent. Even by 2008, mobile phone ownership was no longer correlated to ART proximity. Controlling for time-varying mobile phone take-up does not affect our results (not shown). This suggests that although early take-up of mobile phones (by a very small number of respondents) is correlated with ART proximity, it is unlikely to be generating our results spuriously.

[31]Economic shock variables include income loss, property loss (e.g. fire or flood), death of a breadwinner, divorce, poor harvest, large grain price fluctuations, and other shocks. Unfortunately, since these variables are first available in 2008, there is not enough data to include these shocks as time-varying controls. Instead, we calculate whether the respondent has ever experienced a particular type of shock and include this set of variables (7 in total) interacted with $Post_t$ as controls. This approach measures the respondent's propensity to experience shocks rather than the actual incidence of shocks.

[32]Social support programs include food and education subsidies, nutrition programs, agricultural supports, and unconditional cash transfers. Like the economic shock variables, these data were not collected in all years. We are able to know if the respondent participated in these social support programs (eleven in total) in the two years prior to 2006 and in the two years prior to 2010. We thus have one round of participation data for pre- and post-ART.

the household participation in such programs in the controls.

Finally, we may also worry that respondents who are more likely to benefit from ART move closer to the facilities. Rental housing is largely not available in these villages, so individuals would need to move their farm and build a house in order to move, a very difficult task. Consistent with this, we find that attrition is not correlated with ART proximity (see Appendix Table E.1 and the discussion in the Appendix Section D). We exclude attritors from the entire analysis to ensure that the results are not biased by the changing demographic composition of the sample over time, though the results are similar using the full sample (not shown).

4 Results

To illustrate the identifying source of variation, Figures 3 and 4 plot the main outcomes variables over time by splitting the sample into three groups: near (within 6 kilometers of ART), middle (between 6 and 12 kilometers), and far (more than 12 kilometers).[33] Figure 3 shows the fraction of respondents with any savings and average total savings. Data for savings behavior is only available beginning 2006. By 2008, the impact of ART is already detectable as the fraction of respondents in the "Near" group who report positive savings increases by 15 percentage points, whereas the "Far" group has a slight decrease. The right panel of Figure 3 shows the trends in total amount in savings, which again show little difference in the pre-period.[34] The impact of ART is apparent by 2008, though it is much larger by 2010, which is consistent with what we should expect since savings is a stock variable.

Figure 4 shows the trends in expenditures on education per child in the past three months. The effect of ART only becomes apparent by 2010, which is consistent with what we may expect given that education decisions were likely

[33] The region-by-year effects have been partialled out. This is done to ensure that the trends we observe are not driven by region-specific trends that may arise because of the unequal representation of regions within distance bins.

[34] The fraction of respondents with savings in 2006 is not statistically different by distance group, consistent with pre-characteristics analysis discussed earlier. For total amount in savings, the "Near" group does appear to have slightly more in total savings, though this is sensitive to the cutoff points.

already made by the time ART came online for the 2008 survey rounds.[35] The right panel of Figure 4 shows very similar trends in medical spending per child in the past three months by distance group. In both graphs, we see education and medical spending are similar across groups in 2004 and continue to be similar in 2006 (consistent with the findings in Tables 1 and 2, the respondents are balanced along the distance gradient in trends and levels), indicating little evidence for differential pre-trends by distance to ART.

4.1 ART Availability and Saving Behavior

Estimates of the effect of ART availability on savings behavior appear in Table 3. We show the results using two measures of saving: if the respondent reported any savings and the total amount reported.[36] We find a strong and immediate response in respondents' likelihood to save. The point estimates in column 1, indicate that reducing the respondents' distance to the nearest ART facility by 5.8 km increases the likelihood to save by 9.2 percentage points in 2008 and 10 percentage points in 2010 over the 2006 period.

In column 2, we control for spatial controls such as proximity to any clinic, major market, major road, school, and population density, all interacted with *Post*. In column 3 we add demographic characteristics interacted with *Post*. The demographic characteristics include pre-period wealth score, age, gender, household size, marital status, education, mobile phone take-up, and roof structure. In column 4, we also include economic shocks and participation in government aid programs (also interacted with *Post*).[37]

[35] Moreover, liquidity constrained households may need time to accumulate savings before adjusting their response for larger investments.

[36] As many individuals report zero savings, and very few individuals report positive savings over all three survey years, we use levels in our analysis. In addition, because the distribution is heavily skewed to the right, we capped the total savings to the 99th percentile. This corresponds to a cap at US$600, though the results are not sensitive to the threshold used. Many of the responses in this upper range are likely due to reporting error as they are frequently inconsistent with previous years' responses and other wealth indicators.

[37] Due to the large number of controls, time-invariant controls are interacted with $Post_t$. The results are similar if we interact the controls with year dummies (Appendix Table E.3). The odd columns of this table also provide point estimates on $Post_t \times Clinic\, Proximity_i$ for all the outcomes and show that there is no effect of being near just any medical facility. Note that this exercise is analogous to another placebo test, where we would estimate the

The point estimates for respondents' likelihood to save remain large and significant as we include controls. We also continue to see the same pattern: the share of respondents with any savings increases immediately when ART becomes available but also that the effect increases over time.[38] Due to many missing values, including the set of demographic controls sharply reduces the number of observations. The trends we observe in the point estimates are not due to the changing sample, but a result of including controls.[39]

Column 5 shows that total savings also increase near ART, and the estimated effect is larger and more precise in 2010. The point estimate implies that savings would increase by 19.8 USD during 2006–10 if the respondent's distance to ART were reduced by half, or 5.68 km. This magnitude corresponds to a 44 percent of the average savings held between 2006 and 2010. The results are robust to including spatial, demographic, and economic controls.

4.2 ART Availability and Investment in Human Capital

Estimates of the effect of ART availability on investment in human capital appear in Table 4. We show the response in spending on education, medical, and clothing for children.[40] We find that education and medical spending on children increases with ART availability, while spending on clothing appears to be unaffected. Column 1 shows results for education spending, where the coefficient on 2010 × *ART Proximity* is large, 3.08, and significant; however, the coefficient on 2008 × *ART Proximity* is much smaller, 0.36, and not statistically significant. The point estimate implies that reducing the distance by half would result an increase of 3.08 USD in (quarterly) spending on education per child by 2010. This increase is economically large, representing 80 percent of the average reported spending on education per child during 2004–10.

effect using the distance to clinics that do not provide ART.

[38] The point estimates on 2010 × ART Proximity are always larger than in 2008, though the difference is not statistically significant.

[39] Appendix Tables E.4 and E.5 redo the estimation using the HIV-negative respondents with a balanced panel that has no missing values for the controls. While this restricts the sample size substantially, the results are similar to those presented in the main text.

[40] As with total savings, we use levels for the expenditure outcomes and similarly treat the extreme upper tail of the distributions, but the results are not sensitive to the threshold used. Fewer than 20 observations are affected by the cap per expenditure category.

Columns 2-4 test if the results are robust to including controls. We also include a leading interaction, $2006 \times ART\ Proximity$, to test for pre-trends. The point estimates on $2010 \times ART\ Proximity$ increases to 4.51 when including spatial controls, and decrease to 3.69 when including demographic controls. Including economic shocks and participation in aid programs reduces the point estimate further to 3.22, though it is still significant at the 5 percent level. The point estimates on $2008 \times ART\ Proximity$ become larger with controls, ranging between 0.63 and 1.93, and are suggestive of an effect though they are not precisely estimated. Consistent with the findings in Table 2, the coefficient on ART proximity in 2006 is always small and never statistically different from zero (in all estimates for education, medical, and clothing expenditures).

Column 5 shows results for medical spending, where the coefficient on $2010 \times ART\ Proximity$ is large, 0.68 and significant; however, the coefficient on $2008 \times ART\ Proximity$ is smaller, 0.41 and significantly different from zero only at the 10 percent level. Including spatial controls increases the point estimates, as does including demographic controls, though including economic shocks reduces the point estimate somewhat. Nevertheless, we find a similar pattern as described in other outcomes: the effect of ART begins to become apparent in 2008 and increases by 2010. Unlike for education expenditures, the effect on medical spending appears to be detectible, statistically, by 2008.

We find no evidence that parents are spending more on children's clothing. Respondents were explicitly asked not to include spending on school uniforms. Since clothing is unlikely to contribute to a child's stock of human capital, estimating the effect for clothing expenditures provides a placebo test. If expenditures in general were increasing for reasons not related to ART, for example as a result of an income shock, then we would expect to find evidence of it in clothing expenditures (the largest category of spending on children). Column 9 shows point estimates that are small and slightly negative. Although not a precise zero, the standard errors are relatively small compared to those on the point estimates for education spending (notable since clothing is the largest expenditure parents report for children). The estimates remain close to zero as we include controls.

5 Mechanisms

This section considers possible mechanisms that may result in changes in investment when ART becomes available. We first investigate other investment and income trends to test if another economic shock is causing our results spuriously. We also explore the whether our results are driven through changing mortality patterns. Last, we use the data on perceptions of mortality risk to provide direct evidence of the expectations mechanism.

5.1 Economic Spillovers

The availability of ART may also influence other decisions, notably labor supply, that may indirectly affect investment. For example, Baranov et al. (2012) find that ART availability is associated with improvements in labor supply and that the increased productivity may be driven by improvements in mental health. While our approach cannot rule out the possibility that our results are driven by improvements in mental health, we can consider whether our findings are the result of an income shock. If respondents near ART facilities are cultivating more maize and becoming, effectively, wealthier then we should expect to see increases in spending in other categories as well.

The MLSFH includes expenditure data (recalled for the past three months) for key categories, including spending on the respondents' clothing and medical needs and household spending on seed purchase, agricultural equipment, fertilizer, hired labor, funeral expenses, and medical spending on others.[41] Annual labor earnings are available from 2006 onwards.

Table 5 shows the effect of ART availability on various expenditures in levels, and total expenditures and earnings in logs. The point estimates are small, and in some cases negative, though generally imprecisely estimated. If anything, there appear to be reductions in spending for others' medical spending and hired labor, though these are only marginally significant. The reduction in medical spending for people other than the respondent or the respondent's children, and the reduction in hired labor are consistent with ART

[41] Because of frequent zeros, the estimates for these categories use levels (in USD), treating outliers in the same way as described for expenditures on children.

reducing the caretaking burden and dependency ratio (see below). We also find reductions in spending on fertilizer, which is somewhat counterintuitive since it may be viewed as an investment (though arguably, not nearly as long-term as children's education). Column 9 shows that overall non-child expenditures are decreasing nearing ART, which is consistent with increased savings and spending on other children. Column 10 shows that respondents near ART do not report higher annual earnings (the point estimate is small and slightly negative). The estimates for all expenditures and earnings indicate that our main results are not driven by an income or productivity shock.

5.2 Mechanical Effects of Reducing Mortality

We first rule out the possibility that the results are driven by the direct effect of HIV-positive respondents receiving the life-saving medication by showing that the results are robust to excluding the HIV-positive sample.[42] However, there are other important channels by which ART can impact investment without changing expectations. One possible effect of ART availability is that family members other than the respondent who were ill with AIDS began receiving treatment. This would reduce the burden of taking care of a sick household member.[43] Additionally, because AIDS mostly affects individuals during their most productive age, the sickness and death from AIDS reduces the number of productive members in the household.

Another related effect of ART is a reduction of orphaned children. Orphaned children would often be sent to live with neighbors or extended family, increasing the number of dependents in the household. Such a shift in the household structure increases the caretaking burden and may decrease invest-

[42]Many individuals did not consent to the HIV test (17% of our sample did not have HIV testing results by 2008). The results are also robust to restricting the sample to only HIV-negative respondents (see Appendix Tables E.4 and E.5). The survey did not conduct HIV testing in 2010, so we are unable to exclude individuals who stereoconvert between 2008 and 2010. These individuals would be unlikely to start treatment since a maximum time from infection of two years is generally too short to develop the clinical symptoms to be eligible to start ART (based on local eligibility criteria).

[43]This channel may be potentially large: In South Africa, where a similar ART rollout occurred over a similar time period, Bor et al. (2011) estimate that 25% of the population shared household or compound membership with someone who initiated ART by 2010. However, the HIV prevalence in KwaSulu-Natal was much higher, at 20% of adults.

ment in human capital for even the non-orphaned children. While the total number of orphans may not be large enough to fully explain changes in school enrollment due to changes in life expectancy, the effects of orphanhood may be amplified through their effects on households that care for them. Indeed, in Sub-Saharan Africa, about 20% of households have an orphan living with them (Evans and Miguel, 2007). Since our results are estimated using the same individuals over time, we do not capture any changes in schooling for orphans themselves. However, households near ART may be less likely to receive AIDS orphans after ART becomes available than those who live far.

Table 6 explores whether the mechanisms described above are driving our main results. Panel A estimates the effect of ART availability on savings and investment outcomes excluding the HIV-positives (the result of the panels will also exclude HIV-positives). The point estimates for savings outcomes are very similar to the baseline results. The point estimate for expenditures on children's education is reduced by 27 percent from the baseline specification, which indicates that the HIV-positives were also differentially spending more on children's education near ART.[44]

Panel B restricts the sample to respondents that reported no AIDS-related deaths in the household in the previous two years in all waves of the survey. The questionnaire specifically asks if the death is suspected to be AIDS-related. Because the stigmatization of AIDS may lead to an underreporting of AIDS deaths, we also include any deaths that reported the age of the deceased between 15 and 49 as the large majority of these deaths are caused by AIDS. Panel C excludes respondents who ever reported a seriously ill household member. The results from Panels B and C show that point estimates are similar, though somewhat less precise when excluding deaths or illnesses in the household. The total amount in savings results were also weaker for these groups. Last, to proxy for the presence of orphans, Panel D excludes respondents who ever reported non-biological children co-residing with them.[45] The results are

[44]The results for the HIV-positive sample indicate that they are also increasing investment behavior, though the estimates are imprecise due to the small sample.

[45]Weinreb et al. 2008 identified orphans in the MLSFH data more precisely, but our approach is more conservative and thus preferable here.

similar for all outcomes, but we do find a substantial reduction in the point estimate on education expenditures, with the point estimate for $2010 \times Proximity$ at 1.78, and not statistically different from zero. There is some evidence that the estimates are picking up mechanical effects. However, the overall results remain consistent with the baseline estimates for the HIV-negative sample, suggesting that main driver for our findings is expectations.[46]

5.3 Subjective Expectations

Table 7 reports the estimates for the effect of ART availability on 5-year subjective mortality risk. Column 1 shows the results using the full sample and column 2 excludes respondents who ever tested positive for HIV. The point estimates imply that reducing distance to ART by half would reduce respondents' 5-year mortality risk by 0.058 (0.057 for the HIV-negative sample) by 2010. The results are also displayed graphically in Appendix Figures E.3 and E.4. To get a sense of the magnitude, we use these point estimates to calculate the implied life expectancy gain using mortality tables (outlined in the appendix). The magnitude of the implied subjective life expectancy gain from reducing the distance to an ART facility by 5.8 km is approximately 6.8 years.

Large differences in HIV prevalence exist between men and women in Malawi. In our sample, HIV prevalence among women was 8 percent versus 4 percent in men.[47] Moreover, AIDS mortality for women occurs earlier in life than for men because women are infected at younger ages.[48] The combination of higher prevalence and earlier infection implies that the life expectancy

[46]The reason we find little effects of caretaking is likely because of the number of household with HIV-positive individuals who become sick with AIDS is quite low in the cross-section and would change little between 2008 and 2010 (because the HIV prevalence was about 8% in rural Malawi, and of those that are HIV+ and become sick enough to be eligible for treatment over the 2 years is substantially smaller due to the slow progression of the disease). Over longer time periods, the mechanical effects of reducing illness, death, and orphans should become evident.

[47]2010 DHS estimates for rural Malawi are 10.5% (women) and 7.1% (men) Malawi DHS (2011), with the lower prevalence in the MLSFH population due to the fact that the MLSFH does not include peri-urban areas with higher HIV prevalence that are included in the DHS rural sample Kohler et al. (2014).

[48]This is likely a result of young women dating older men because the older men have more money, a common practice throughout Sub-Saharan Africa. Additionally, the difference in prevalence can partly be explained by transmission probabilities.

gains from ART for women are substantially larger than the life expectancy gains for men.[49] These difference are reflected in the subjective mortality risk response of MLSFH respondents. Table 7, columns 3 and 4 show the results for subjective mortality risk for women and men, respectively. The point estimate on the 2010 coefficient shows that ART availability decreases mortality risk for women by 0.064, and for men by 0.045. These point estimates correspond to implied life expectancy gains of 8.5 and 6.2, respectively.

Another limitation we have is that we observe subjective mortality for respondents but not their children. It may be the case that adults believe that their children will have access to treatment regardless of location. Unfortunately, we do not directly measure parents' beliefs about their children's mortality risk. As an indirect measure, we estimate the change in subjective mortality risk for the youth sub-sample in column 5 of Table 7. The results are large and significant, despite the small sample size, indicating that there does not seem to be a generational gap in the effect of ART availability.

6 Life Expectancy and Schooling

Our results thus far suggest that ART availability resulted in increased spending on children's human capital by way of changing perceptions about longevity. To further strengthen this conclusion, we also estimate the effect of ART availability on children's grade attainment as reported by their parents.[50] Table 8 provides results using the sample of respondents' children who are of school age (5–19) and are reported in the 2006, 2008, and 2010 years of the survey. We chose to use grade completion (and control for age times year in all regressions) rather than grade-for-age for ease of interpretation, although using grade-for-age yields similar results.[51] Including spatial and demographic controls slightly increase the point estimates on grades completed. The effect of

[49]UN life tables suggest that the estimated life expectancy gains from eliminating AIDS mortality are 11.1 years for men compared to 14.4 years for women).

[50]The survey only asks about grade attainment, which, due to grade repetition, is generally less than total years of schooling.

[51]Additionally, children's age is often estimated by the parent so including it in the dependent variable adds noise that is difficult to interpret. In the regressions, we use the mean reported age over the three surveys, which ideally corresponds to the age in 2008.

ART on grade completion seems to be quite large. The point estimate in column 1 implies that decreasing the distance to ART by half would increase years of schooling by 0.25 in the full sample, and the estimate increases to 0.33 in the sample excluding HIV-positive parents (column 2). The effect is only large and significant by 2010, which is consistent with the lagged response of educational spending. The results are robust to including spatial and demographic controls (see Appendix Table E.6 and E.7).[52]

Since ART increases life expectancy for adults and children, the results presented in Table 8, columns 1 and 2, include the effect of life expectancy gains for parents and children. However, we wish to calculate the implied effect of an additional year of children's life expectancy on schooling to estimate the horizon effect outlined in human capital theory (Ben-Porath 1967).[53] To estimate this effect of children's life expectancy on years of schooling without capturing the effect of parental longevity, we exploit differential life expectancy gains by gender.[54] We use a triple-difference model to estimate the additional increase in grade attainment girls received relative to boys as a result of ART:

$$y_{ijrt} = \beta Girl_i \times Post_t \times Proximity_{ijr} + Girl_i \times Post_t + \alpha_{ijr} + \delta_{rt} + \varepsilon_{ijrt}. \quad (6.1)$$

We include age-by-year effects, individual fixed effects and region-year effects

[52]We also find evidence of improvements in child health. Theory predicts that parents expecting to live longer should invest in their children's health, because it will enable them to earn higher wages as adults. Appendix Table E.6, cols 4-6, show that by halving the distance to ART, parents are 12 percentage points more likely to report their child to be in excellent health by 2008 and 14 percentage points by 2010 (those percentages are 14 and 15, respectively, when excluding HIV-positive parents). Including spatial and demographic controls reduces the point estimates slightly, but substantially decreases the precision.

[53] If ART only increases life expectancy for the respondents but not their children, the rate of return to education from the perspective of the child is not affected. However, the parents are now more likely to live into old age and receive benefits from investments in child human capital through upward intergenerational transfers (Banerjee 2004). Holding fixed the life expectancy of the parents, when children are expected to live longer, the rate of return to education from the perspective of the child has increased. Therefore, since ART increases life expectancy for adults as well as children, there are two relevant margins that push toward higher investment in human capital. A simple model outlining these results is presented in Appendix B.

[54]This approach is similar to that of Jayachandran and Lleras-Muney (2009).

and allow individual indicators for 2010 and 2008 instead of *Post*.[55]

Columns 3 and 4 show the differential impact of ART availability by girls and boys in a triple difference regression. The point estimates on the triple difference are not precise. We also include results for a restricted sample of only older children, since the younger children may not have yet had a chance to drop out. These results give slightly higher estimates and are significant at the 10% level. Although the standard errors are large (potentially because of the limited sample size), they are robust to including various controls (see Appendix Table E.7). The estimates suggest that girls' schooling attainment increases by 0.38 years more than for boys. Given that the life expectancy gains for girls are 3.3 years greater than for boys, we can divide these numbers to get a "back-of-the-envelope" estimate of the effect: These results imply that the marginal effect of an extra year of life expectancy on years of schooling is 0.08 (or 0.12 using the results for the older children).[56] The magnitude of the effect is very similar to that estimated by Jayachandran and Lleras-Muney (2009), and more recently by Hansen (2013).

7 Conclusion

While economic theory predicts that a longer life expectancy increases the value of long-term investments such as education, it has ambiguous predictions for saving behavior. Recent studies provide compelling evidence suggesting that education responds to life expectancy; however, few studies have considered the effects on savings. This paper uses spatial and temporal variation in the availability of life-extending AIDS medication to evaluate its impact on savings and human capital investment in Malawi. Our study has several advantages: it allows us to estimate the effects of ART on the savings behavior and human-capital investments of HIV-*negative* individuals, that is, individuals who do not directly benefit from receiving ART. In addition, we use data on

[55]This model implies the assumption that parents are not more likely to invest in girls versus boys for reasons other than their different life expectancy gains. We look for evidence of a gender bias in educational attainment before ART is introduced in the children's sample and the youth respondents. If anything, boys have slightly higher grade attainment.

[56]This calculation is biased downward as we attribute the change in grade attainment, which is estimated using the distance gradient, to the full difference in life expectancy gains.

self-reported mortality risk to provide direct evidence that individuals actively change investment decisions based on their subjective longevity.

We employ a difference-in-difference strategy to estimate the impact of ART availability on savings, education expenditures, and children's schooling. The identification strategy compares the investment outcomes of people who live near and far from ART, before and after it became available.

We find large effects of ART availability on reported savings and investment in children's human capital. Consistent with these findings, we also show that ART availability improves educational attainment for children of the respondents. For example, halving the distance to ART (a decrease of approximately 5 kilometers for the average respondent) would imply an increase in schooling by 0.3 years. The results are similar for the HIV-negative respondents, indicating that the results are not driven by the direct effect of HIV-positive individuals receiving life-saving medication. Other potentially important channels not related to changing expectations, such as the household caretaking burden from AIDS-related illness, death, and orphanhood, cannot explain our findings. However, ART availability does have a measurable decrease in self-reported mortality risk.

Taken together, these results suggest that our findings are due to changes in expectations about longevity, and provide compelling evidence in favor of the mechanism in human capital theory. The savings results also provide evidence that higher life expectancy does prompt more savings.

Our findings also have important policy implications. We show that antiretroviral therapy leads to large and economically important increases in savings and investment behavior both for HIV-positive and for healthy individuals. This spillover benefit should be incorporated into cost-benefit analyses of such programs by governments and donor organizations. Our results also suggest that the impact of ART may have large implications for economic growth in sub-Saharan Africa.

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Figures and Tables

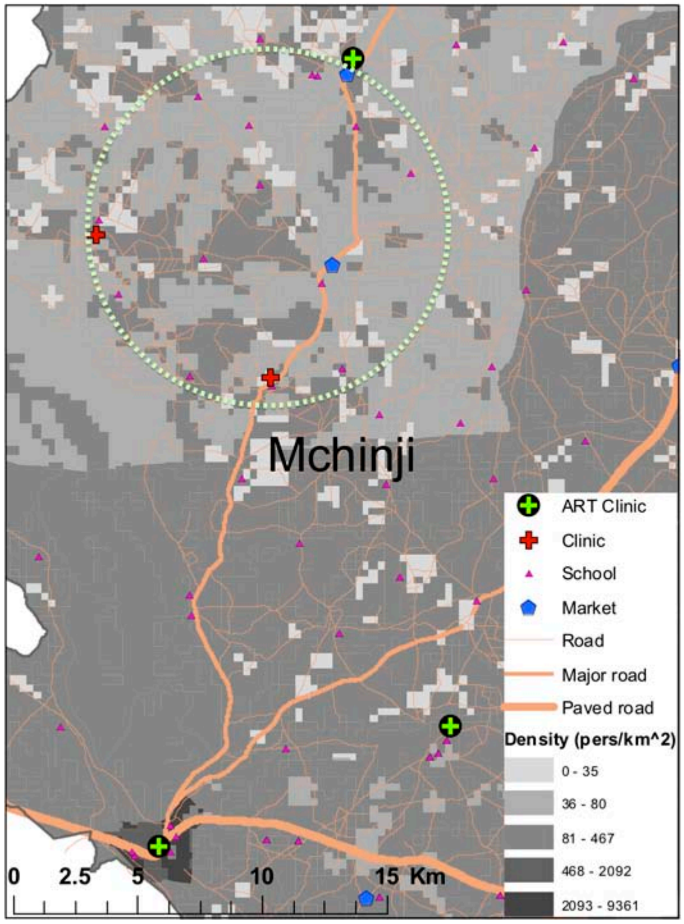

Figure 1 – Map of Mchinji (sample of respondents from circled region)

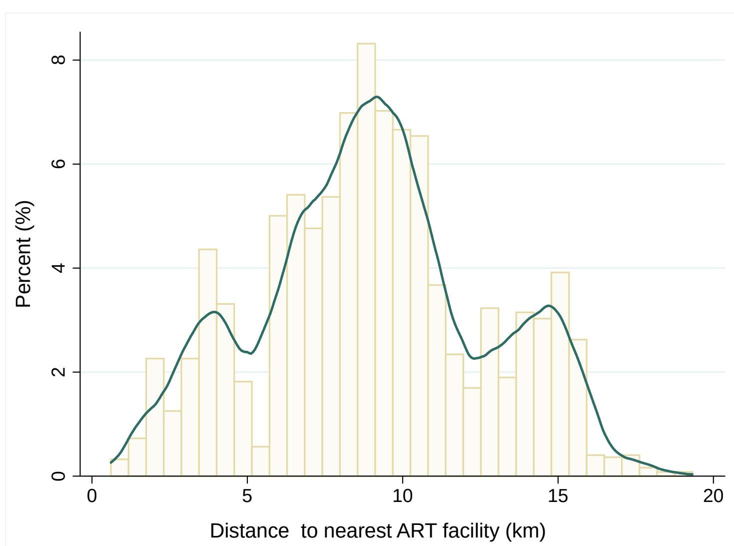

Figure 2 – Kernel Density for Distance to ART Facility in 2008

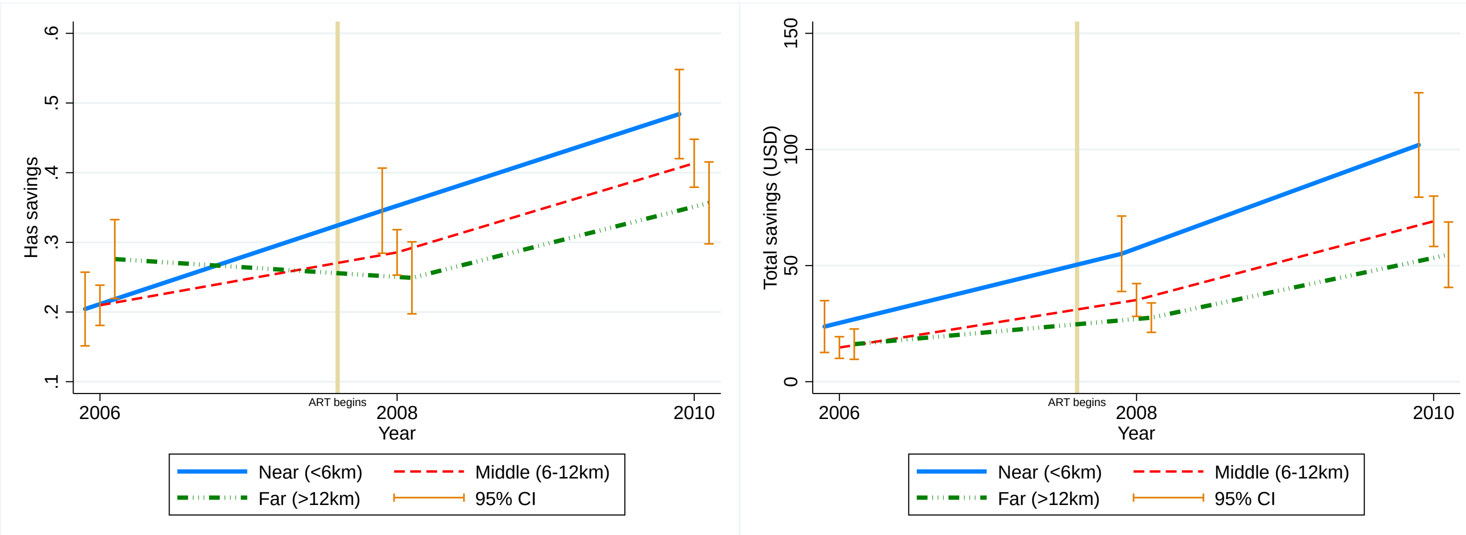

Figure 3 – Trends in saving behavior by distance to ART

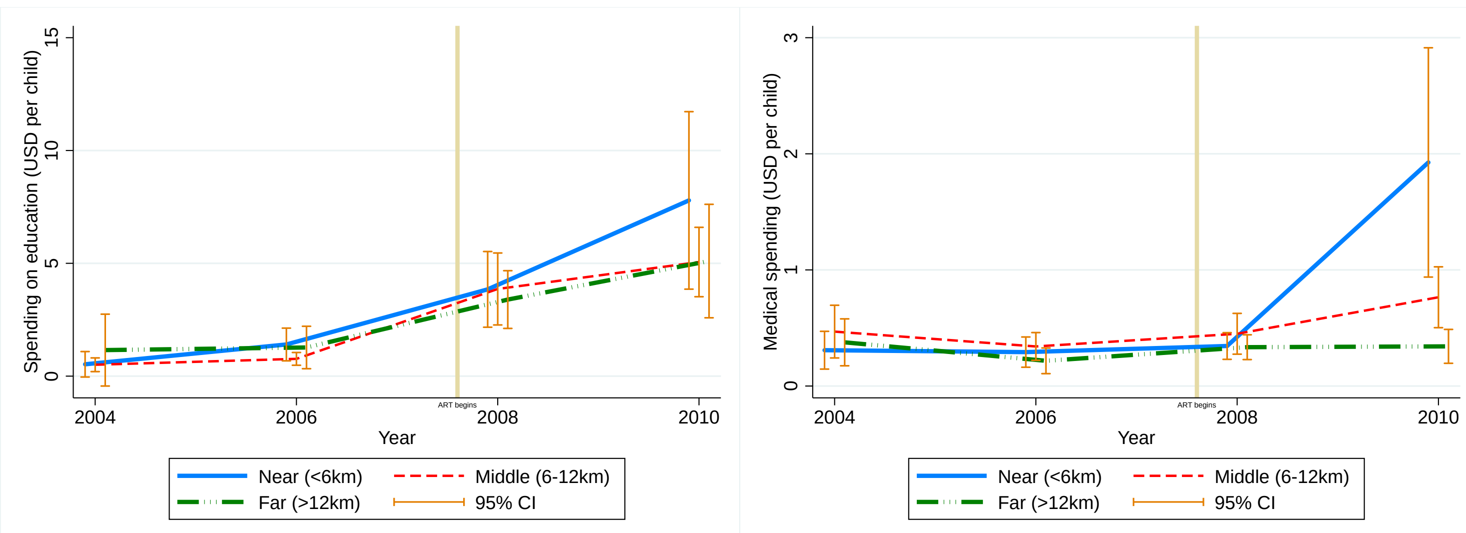

Figure 4 – Trends in spending on education and medical spending by distance to ART

Table 1 – Pre-ART (2006) characteristics of the MLSFH study population

	Mean	St. Dev.	Coefficient on ART Proximity: No controls	With controls
	(1)	(2)	(3)	(4)
Panel A: Demographic and Economic Characteristics (2006)				
Age	36.85	13.1	−0.46	−0.72
Household size	5.46	2.3	−0.17	−0.31
Education (grades completed)	5.10	3.5	0.24	0.41
Labor income (USD)	80.58	215.8	21.4*	−1.96
Wealth index	0.11	2.0	0.20	0.10
Land (hectares)	1.59	1.5	−0.05	−0.01
High discount rate	0.66	0.5	−0.04	−0.06
Has metal roof	0.15	0.4	0.07**	0.08*
Has bicycle	0.58	0.5	0.04	0.03
Has radio	0.76	0.4	0.02	−0.02
Has mobile phone	0.04	0.2	0.02	0.05***
Panel B: HIV, Health, and Risk Perceptions (2006)				
HIV Positive	0.04	0.2	−0.01	0.00
Perceived HIV Risk	0.10	0.2	0.04***	0.04***
Likelihood of HIV Infection (Likert)	0.36	0.7	0.11***	0.08
Physical Health Score (PCS12)	52.50	7.2	−0.50	−0.78
Mental Health Score (MCS12)	55.57	8.0	−1.03**	−0.57
Know someone on ART	0.50	0.5	0.04	−0.03
Worried about AIDS	0.27	0.4	0.03	0.03
Mortality risk (5 year; own)	0.39	0.2	0.05***	0.01
Perceived HIV prevalence	0.28	0.2	0.02	0.02
No. of relatives sick/died of AIDS	1.51	1.9	0.09	0.08
Panel C: Savings and Expenditures on Children (2006)				
Has savings	0.22	0.4	−0.03	−0.05
Savings (USD)	17.14	66.9	3.38	−4.53
Education (USD/child)	1.38	4.3	0.10	0.32
Medical (USD/child)	0.41	1.2	0.03	0.01
Clothing (USD/child)	2.25	4.2	0.24	0.20
Panel D: Child Outcomes and Characteristics (2006)				
Grades completed	2.74	2.0	0.27	0.08
Subjective health score (1-5)	4.14	0.8	−0.18**	−0.08
Age	10.03	2.8	0.34	0.16
Panel E: Spatial Characteristics				
Distance to ART in 2006 (km)	26.42	4.9	4.02***	
Distance to ART in 2008 (km)	9.10	3.6	−6.84***	
Distance to clinic (km)	6.11	3.1	−3.48***	
Distance to major market (km)	5.29	3.8	−3.72***	
Distance to major road (km)	4.98	3.5	−1.78***	
Distance to school (km)	1.66	1.0	−0.09	
Population Density (pers/km^2)	100.68	55.9	−16.0**	

$N = 1379$. For child sample (Panel D), $N = 525$. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Note: This table describes characteristics of respondents and their children in 2006, before ART became available. Columns (3) and (4) report the coefficient on ART proximity (parameterized as the negative log distance) from regressing each variable on ART proximity and stars indicate significant coefficients. Column (3) only controls for region dummies, while column (4) controls for spatial characteristics (described in detail in the text). The sample of survey respondents is restricted to those who were interviewed in all three years for the main analysis (2006, 2008, and 2010). Panel D describes characteristics of the respondents' children and is restricted to children who were reported in the household roster for all three years.

Table 2 – Pre-ART Trends: Changes between 2004–2006

	Mean	St. Dev.	Coefficient on ART Proximity: No controls	With controls
	(1)	(2)	(3)	(4)
Panel A: Demographic and Economic Characteristics				
Household size	-0.38	2.3	−0.30**	−0.36
Education (grades completed)	0.18	3.3	0.21	0.31
Wealth index	0.04	1.2	−0.12	−0.08
Land (hectares)	0.16	1.6	0.03	−0.14
High discount rate	0.19	0.6	−0.03	−0.02
Has metal roof	0.02	0.2	0.01	0.01
Has bicycle	0.05	0.5	−0.02	−0.03
Has radio	0.02	0.5	−0.06	−0.04
Has mobile phone	0.03	0.2	0.02	0.04**
Panel B: HIV, Health, and Risk Perceptions				
HIV positive	0.01	0.1	0.00	0.00
Likelihood of HIV Infection (Likert)	-0.24	1.1	0.14*	0.04
No. of relatives sick/died of AIDS	0.43	2.2	0.03	0.21
Perceived HIV prevalence	-0.12	0.3	−0.02	0.00
Know someone on ART	-0.18	0.4	0.02	−0.03
Worried about AIDS	-0.28	0.5	0.04	0.08
Panel C: Expenditures on Children				
Education (USD/child)	0.10	1.3	−0.05	0.09
Clothing (USD/child)	0.23	4.7	−0.69	0.15
Medical (USD/child)	-0.08	1.5	0.11	0.41

$N = 1358$ * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Note: This table shows the mean changes between 2004 and 2006 (i.e., the period before ART came online in the MLSFH study regions) in available outcomes and characteristics of the sample. Columns (3) and (4) report the coefficient on ART proximity (parameterized as the negative log distance) from regressing the change in each variable on ART proximity and stars indicate significant coefficients. Column (3) only controls for region dummies, while column (4) controls for spatial characteristics.

Table 3 – ART Availability and Saving Behavior

Dependent variable:	Any savings				Savings (USD)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2010 × ART Proximity	0.10***	0.14***	0.17***	0.16***	19.8***	25.6***	29.6***	23.2**
	(0.035)	(0.046)	(0.055)	(0.060)	(5.71)	(9.82)	(10.9)	(11.5)
2008 × ART Proximity	0.092**	0.13***	0.13**	0.12**	13.3*	19.1*	19.2*	13.4
	(0.041)	(0.048)	(0.058)	(0.061)	(6.98)	(10.0)	(11.3)	(11.4)
Observations	3989	3989	3201	3125	3984	3984	3196	3123
Within R2	0.079	0.083	0.089	0.099	0.11	0.12	0.13	0.14
F-statistic	29.0	17.8	8.75	30.0	30.8	16.2	21.5	33.0
Mean of dep. variable	0.32	0.32	0.33	0.33	44.8	44.8	46.0	46.2
Spatial controls	–	Yes	Yes	Yes	–	Yes	Yes	Yes
Demo. controls	–	–	Yes	Yes	–	–	Yes	Yes
Shocks & aid programs	–	–	–	Yes	–	–	–	Yes

* $p < .10$, ** $p < .05$, *** $p < .01$

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects and region-by-year dummies. The sample is restricted to individuals who were interviewed in all three years of the survey (2006, 2008, and 2010). Spatial controls include population density and proximity to clinic, market, major road and school (interacted with $Post_t$). Demographic controls include pre-period wealth, roof material, if the respondent has a mobile phone, age, household size, gender, education, and marital status (interacted with $Post_t$). Controls for economic shocks and other aid programs are described in detail in the text.

Table 4 – ART Availability and Expenditures on Children

Dependent variable:	Education (USD)				Medical (USD)				Clothing (USD)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
2010 × ART Proximity	3.08**	4.51***	3.69**	3.22**	0.68***	0.88***	0.94***	0.75***	-0.05	0.85	0.80	0.70
	(1.29)	(1.52)	(1.56)	(1.36)	(0.22)	(0.30)	(0.31)	(0.28)	(0.77)	(0.91)	(0.91)	(0.85)
2008 × ART Proximity	0.36	1.93	1.22	0.63	0.41*	0.63**	0.67**	0.49**	0.28	1.24	1.19	1.03
	(0.74)	(1.27)	(1.39)	(1.36)	(0.22)	(0.30)	(0.30)	(0.24)	(0.79)	(0.94)	(0.96)	(0.90)
2006 × ART Proximity		0.58	0.75	0.84		0.18	0.20	0.23		0.15	0.16	0.14
		(0.61)	(0.57)	(0.56)		(0.15)	(0.15)	(0.15)		(0.65)	(0.68)	(0.66)
Observations	2708	2708	2572	2506	2767	2767	2631	2564	2764	2764	2629	2562
Within R2	0.10	0.10	0.14	0.15	0.03	0.04	0.04	0.06	0.13	0.14	0.15	0.15
Mean of dep. variable	3.84	3.84	3.88	3.90	0.56	0.56	0.57	0.57	4.36	4.36	4.42	4.46
Spatial controls	–	Yes	Yes	Yes	–	Yes	Yes	Yes	–	Yes	Yes	Yes
Demo. controls	–	–	Yes	Yes	–	–	Yes	Yes	–	–	Yes	Yes
Shocks & aid programs	–	–	–	Yes	–	–	–	Yes	–	–	–	Yes

* $p < .10$, ** $p < .05$, *** $p < .01$

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, region-by-year dummies, and month of interview controls. The sample is restricted to respondents with school-age children and regressions are weighted by inverse of number of household respondents. All regressions use data from 2004. Spatial controls include population density and proximity to clinic, market, major road and school (interacted with $Post_t$). Demographic controls include pre-period wealth, roof material, if the respondent has a mobile phone, age, household size, gender, education, and marital status (interacted with $Post_t$). Controls for economic shocks and other aid programs are described in detail in the text.

Table 5 – ART Availability and Other Expenditures

Dependent variable:	Clothing (Own)	Medical (Own)	Medical (Others)	Funeral	Seed	Farm Equipt	Fertilizer	Hired Labor	Total Exp *ln*(USD)	Earnings *ln*(USD)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2010 × ART Proximity	-0.46	0.30	-1.27*	0.055	-0.18	-0.39	-3.98**	-2.38*	-0.36*	-0.083
	(1.50)	(0.49)	(0.71)	(0.35)	(0.28)	(0.39)	(1.62)	(1.37)	(0.19)	(0.14)
2008 × ART Proximity	0.97	0.21	-1.12	0.24	0.070	0.027	1.41	-0.71	-0.12	-0.19
	(1.43)	(0.43)	(0.72)	(0.42)	(0.18)	(0.18)	(1.04)	(1.42)	(0.19)	(0.13)
2006 × ART Proximity	-0.28	-0.090		-0.22	0.065	0.092	2.31	1.35		
	(0.91)	(0.30)		(0.31)	(0.16)	(0.18)	(1.43)	(0.98)		
Observations	3456	3456	1006	3456	3456	3456	3456	3456	2646	2820
Within R2	0.13	0.08	0.03	0.03	0.05	0.04	0.07	0.05	0.13	0.42
Mean of Dependent Variable	9.56	1.92	0.87	1.25	0.67	0.88	5.38	4.87	2.68	4.46

* $p < .10$, ** $p < .05$, *** $p < .01$

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, region-by-year dummies, and month of interview controls. The sample is restricted to individuals who were interviewed in all three years of the survey (2006, 2008, and 2010). Estimates for columns 1,2, and 4-8 also use data from 2004. Because of frequent zeros, the estimates in columns 1-8 use levels of total spending as the dependent variable.

Table 6 – ART Availability and Investment – Mechanisms

	Saving Behavior		Expenditures on Children (USD)		
Dependent variable:	Any savings	Savings (USD)	Education	Medical	Clothing
	(1)	(2)	(3)	(4)	(5)
Panel A: Excluding HIV-positive respondents					
2010 × ART Proximity	0.11***	19.2***	2.25**	0.61***	-0.31
	(0.032)	(5.91)	(1.02)	(0.23)	(0.80)
2008 × ART Proximity	0.099**	15.0**	-0.018	0.18	-0.28
	(0.042)	(7.60)	(0.73)	(0.12)	(0.74)
Observations	3809	3803	2592	2649	2646
Panel B: Respondents who never reported an AIDS-related death in previous 2 years					
2010 × ART Proximity	0.14***	12.5	2.26*	0.87***	-0.80
	(0.044)	(8.21)	(1.33)	(0.32)	(1.08)
2008 × ART Proximity	0.11**	9.45	-0.60	0.043	-0.60
	(0.047)	(8.85)	(0.61)	(0.15)	(0.92)
Observations	2782	2777	1865	1908	1907
Panel C: Respondents who never reported a seriously ill household member					
2010 × ART Proximity	0.11***	17.4**	2.20**	0.63**	-0.08
	(0.036)	(7.49)	(1.09)	(0.25)	(0.77)
2008 × ART Proximity	0.082*	12.1*	0.32	0.20	-0.22
	(0.044)	(6.45)	(0.72)	(0.13)	(0.75)
Observations	3404	3398	2315	2366	2363
Panel D: Respondents who never reported non-biological children living with them					
2010 × ART Proximity	0.12**	26.0***	1.78	0.70**	0.07
	(0.049)	(9.23)	(1.63)	(0.28)	(1.29)
2008 × ART Proximity	0.076	2.78	-0.89	0.31*	-0.16
	(0.047)	(8.75)	(0.90)	(0.17)	(0.96)
Observations	2074	2071	1205	1238	1238
Mean of Dependent Variable	0.32	45.5	3.67	0.56	4.36

* $p < .10$, ** $p < .05$, *** $p < .01$

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects and region-by-year dummies. The sample is restricted to individuals who were interviewed in all three years of the survey (2006, 2008, and 2010). Regressions reported in columns 3-5 are restricted to respondents with school-age children and weighted by inverse of number of household respondents. Columns 3-5 also use data from 2004. All regressions exclude HIV-positive respondents.

Table 7 – ART Availability and Subjective Expectations

Dependent Variable:	5-year Subjective Mortality Risk				
Sample:	Full sample	Excluding HIV-pos.	Women	Men	Youth (age 16-20)
	(1)	(2)	(3)	(4)	(5)
2010 × ART Proximity	-0.058**	-0.057**	-0.064***	-0.045	-0.10**
	(0.023)	(0.024)	(0.025)	(0.032)	(0.051)
2008 × ART Proximity	-0.038*	-0.037	-0.073***	0.022	-0.064
	(0.022)	(0.025)	(0.027)	(0.029)	(0.047)
Observations	3943	3766	2300	1626	420
Within R2	0.04	0.04	0.05	0.04	0.09
Mean of Dependent Variable	0.41	0.41	0.43	0.38	0.37

* $p < .10$, ** $p < .05$, *** $p < .01$

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects and region-by-year dummies. The sample is restricted to individuals who were interviewed in all three years of the survey (2006, 2008, and 2010). The dependent variable is self-reported 5-year mortality risk.

Table 8 – ART Availability and Children's Grade Attainment

Dependent Variable:	Highest Grade Completed			
Sample:	All children	Excluding HIV-pos	Excluding HIV-pos	Older children
	(1)	(2)	(3)	(4)
Girl × 2010 × ART Proximity			0.27	0.38*
			(0.21)	(0.22)
Girl × 2008 × ART Proximity			-0.03	0.00
			(0.15)	(0.16)
2010 × ART Proximity	0.25**	0.33***	0.24*	0.25*
	(0.13)	(0.12)	(0.13)	(0.14)
2008 × ART Proximity	0.07	0.09	0.09	0.10
	(0.09)	(0.09)	(0.11)	(0.11)
Observations	1578	1521	1521	1368
Within R2	0.69	0.69	0.69	0.69
Mean of Dependent Variable	3.68	3.70	3.70	3.94

* $p < .10$, ** $p < .05$, *** $p < .01$

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include child fixed effects and region-by-year dummies. The sample is restricted to children who were reported in all three years of the survey (2006, 2008, and 2010). Regressions are weighted by inverse of number of children per household. Except for column 1, regressions exclude children whose parents ever tested positive for HIV. Columns 3 use the full sample of children aged 5-19, and column 4 only includes children who were older than 12 years old by 2010.

Appendix: For Online Publication

A Theoretical Predictions

This section briefly describes the theoretical predictions for the effect of increasing life expectancy on savings and human capital investment.[57] First, we discuss how life expectancy gains may influence savings in models of life-cycle savings, precautionary savings, and savings for investment in a credit constrained environment.

In the life-cycle model of savings, increasing longevity implies that individuals are more likely to live into old age when income is low, thereby increasing motivation to save (Bloom et al. 2003; Freire 2004; Lee et al. 2000; Zhang and Zhang 2005). However, improvements in longevity are often associated with reductions in morbidity, lengthening the working life and reducing the need to save (Fogel 1994, 1997). The implications on saving also depend on the prevailing life-cycle patterns of production and consumption (Lee and Mason, 2011; Deaton, 1989), and may be very different in countries with little old-age dependency (as is the case in low income SSA countries) as compared to countries with extended periods of old-age dependency.

Precautionary savings are another motivation for saving, particularly in developing countries.[58] For example, individuals may hold savings in anticipation of future illness, funeral costs, or bequests (Van de Kuilen and Lammers 2007; Freire 2004). If individuals were saving to insure themselves against an AIDS-related shock, then precautionary savings may decrease when ART becomes available. On the other hand, individuals may be more likely to save if those savings were to go toward procuring ART.[59]

Lastly, individuals may be saving to self-finance investments when credit is not available (Fafchamps and Pender 1997). Since long-term investments

[57]In addition, life expectancy also plays a role in decisions about fertility (Fortson 2009; Shapira 2010) and labor supply (McLaren 2010).

[58]In general, it is not clear that an increase in life expectancy should have an effect on precautionary savings.

[59] While the medication itself is free, there are additional costs of food and care during the time the patient recovers once they start treatment.

become more attractive when longevity rises, liquidity-constrained individuals may increase savings in order to finance these investments.

Individuals may save for any combination of reasons described above, thereby making it difficult to *a priori* predict the effect of a life expectancy increase on savings.

B Model of Human Capital Investment

We present a model of human capital investment in the vein of Banerjee (2004) in which both adults and children may have life expectancy shocks. There are two periods: "young" when parents invest in children's schooling, and "old" when parents receive help from their children. Let h represent investment in the human capital of the child. Let δ^A represent the survival probability of the parent into the second period (old age), and δ^C represent the survival probability of the child into adulthood (when the parent is old). The rate of return to the child's human capital for the parent is ρ. The parent's problem is therefore

$$\max_{h \geq 0} \quad u(y_1 - h) + \beta\delta^A u\left(y_2 + \delta^C h(1+\rho)\right).$$

The child's survival probability is the probability that the parent received the payout in old age. We assume that y_2, the income in old age, is low enough such that the parents always invests a positive amount into their children (in the case of log utility, this requires that $\beta\delta^A\delta^C(1+\rho)y_1 > y_2$). Assume, for exposition, that we can parametrize utility using the log function. Then the solution is

$$h(\delta^A, \delta^C) = \frac{\beta\delta^A\delta^C(1+\rho)y_1 - y_2}{\delta^C(1+\rho)\left[\beta\delta^A + 1\right]}, \tag{B.1}$$

which is positive because we have assumed the parents' old age income relative to adulthood income was much lower. Holding fixed the survival probability of the child, an increase in the parents' survival probability would increase investment in human capital, $\frac{\partial h}{\partial \delta^A} = \frac{\beta\left[\delta^C(1+\rho)y_1 + y_2\right]}{\delta^C(1+\rho)(\beta\delta^A+1)^2} > 0$. Similarly, holding fixed the parents' survival probability, an increase in the child's survival probability would also increase investment in human capital: $\frac{\partial h}{\partial \delta^C} = \frac{y_2}{\delta^{C^2}(1+\rho)(\beta\delta^A+1)} > 0$. Lastly, if both parent and child survival probabilities increase at the same time, then human capital would also increase. For example, assume that $\delta^A = \delta^C = \delta$, then

$$\frac{\partial h}{\partial \delta} = \frac{\beta\delta^2(1+\rho)y_1 + (2\beta\delta+1)y_2}{\delta^2(1+\rho)[\beta\delta+1]^2} > 0. \tag{B.2}$$

Thus, the increase in investment in human capital as a result of a life expectancy shock that affects both generations would be larger than the response to life expectancy shock that affects only children. [60] While the overall response to the life expectancy increase from ART is important, we are also interested in estimating the parameter, $\frac{\partial h}{\partial \delta^C}$, to test the prediction from the standard model of human capital accumulation (Ben-Porath 1967; Becker and Tomes 1979). We take advantage of the differential life expectancy gain by gender and compare the schooling gain for girls relative to boys to identify the marginal effect of the child's life expectancy on schooling.

C Effect of ART on Subjective Life Expectancy

In this section, we calculate the implied effect on subjective life expectancy (SLE) from the estimates on 5-year mortality risk reported in Section 5.3. Using the estimates of the impact of ART availability on subjective mortality risk as the first-stage is a valid approach if our identification strategy was only picking up the effect expectations. The implied subjective life expectancy is calculated by adjusting the age-specific mortality rates from life tables.[61] Based on that calculation, we report the effect of ART availability on subjective life expectancy. We can then compare the effect on subjective life expectancy to estimates of actual life expectancy gains from eliminating AIDS mortality.

The life tables provide age-specific mortality rates in 5-year increments (e.g., mortality rate for the age group 20-24). To estimate the implied life expectancy gain, we adjusted the age-specific mortality rates between the ages

[60] The amount of additional human capital investment due to the parent's life expectancy gain, $\frac{\partial h}{\partial \delta} - \frac{\partial h}{\partial \delta^C}$, is $\frac{\beta\delta(1+\rho)y_1+\beta y_2}{\delta(1+\rho)[\beta\delta+1]^2} > 0$.

[61] We use life tables from the UN Population Division for Malawi in 2009 since these are calculated based on mortality data the 5 years prior, which corresponds best to the years of the survey.

of 15 and 49 (this is generally the age range for which HIV prevalence is reported), although the calculation is not particularly sensitive to extending the mortality decreases beyond 49 (to, say, 69). The estimated effect on 5-year mortality risk from our respondents is an average based on all respondents and is not age-specific. While it would be possible to estimate the effect of ART on 5-year mortality risk for each age group, the estimates become less precise. Thus we use the overall effect of ART on 5-year mortality risk to adjust the age-specific mortality rates in the age groups where AIDS mortality is occurring.

We take two approaches in interpreting the bean measure as a probability. In the first, we assume that the level change in subjective mortality risk reported using beans is an accurate reflection of the respondents' risk assessment. In this case, we apply the 5.8 percentage point decrease to the relevant age categories.[62] The second approach assumes that the level of mortality risk that individuals report does not reflect their true beliefs, but that the percentage change over the level is meaningful. Then 5.8 percentage points more accurately reflects a 15 *percent* decrease in mortality risk (since the average perceived mortality risk before ART was 0.39). We do this second approach because we may be concerned with interpreting the response in levels, given the levels of perceived mortality risk are high as compared to life-table based estimates of mortality risks (Delavande and Kohler, 2009) seem implausibly high. We then apply a 15 percent decrease to the 5-year death probabilities to the relevant age categories in the life tables. These two approaches yield different results: the first approach using levels implies a life expectancy (at age 5) gain of 6.8 years, whereas the second approach implies a life expectancy gain of 4.2 years. We should note that these subjective life expectancy gains are estimated off of the distance gradient, and should be interpreted as the effect on SLE when moving ART 5.8 km closer to the respondent.

We can compare these subjective life expectancy gains to the estimated

[62]Except for the 15-24 age groups, which we treat separately, since that would result in negative mortality probabilities. Here we smooth the values by interpolating the decrease in mortality risk linearly.

life expectancy gains of eliminating AIDS in Malawi (UN World Population Prospects, 2010 Revision). According to these estimates, eliminating all AIDS mortality in Malawi would lead to an increase in observed life expectancy of 12.7 years. The gains provide a reasonable upper bound for the effect of ART on subjective life expectancy, since ART medication does not entirely eliminate AIDS mortality.[63] In light of the large change in objective risk, the strong response in subjective mortality risk and other behavior changes among the HIV-negative sample does not seem implausible.

D Attrition Analysis

Appendix Table E.1 provides summary statistics by attrition status and shows significant differences between attritors and non-attritors. Attritors tended to be younger, male, unmarried, more educated, closer to major roads, and more likely to be HIV-positive. Our results are estimated using the set of respondents that are present for all three years of the survey from 2006-2010, though the results are similar using the entire sample of respondents.[64] Because of this balance, our results are internally valid (even if there is attrition) as long as attrition is not correlated with ART proximity. We worry that individuals who live far from ART and are forward-looking may move closer to ART facility (and thus attrit from the sample). Thus the sample of respondents that remain in the analysis would include both types (forward-looking and not) in the near areas and only present-biased types in the far areas. Several pieces of evidence suggest this is not the case. First, attrition is not correlated with ART proximity, which can also be seen in Table E.1 as the "Distance to ART in 2008" (Panel E) in columns 1 and 2 are not statistically different (if anything attritors were closer to ART facilities). Second, attritors did not appear to be

[63] The life expectancy gains may seem high given the prevalence of HIV. It is useful to realize that the lifetime risk of getting HIV is also much higher than the prevalence, and in a country with 10 percent prevalence the lifetime risk of HIV is approximately 45 percent (Blacker and Zaba 1997).

[64] For regressions with 2004 data, we use the available data for those respondents that were interviewed in 2004, but still use the respondents that have missing data in 2004. This is done because a new respondents were recruited in 2006, and so eliminating them from the analysis would be deplete the sample size.

less present biased, there is no difference in whether the respondent exhibited a "High discount rate" (Panel B) by attrition status.

Appendix Table E.1 also repeats the balancing tests (regressing characteristics on ART proximity controlling for spatial characteristics) for the attritor sample. Among attritors, people near ART were more likely to be HIV-positive and report more sick relatives that died of AIDS. Attritors near ART also had more education. And they were more likely to have a mobile phone, a pattern that also appeared with the non-attritors. However, there was balance in the main outcomes of interest (Panel D), even among attritors.

E Appendix of Graphs and Tables

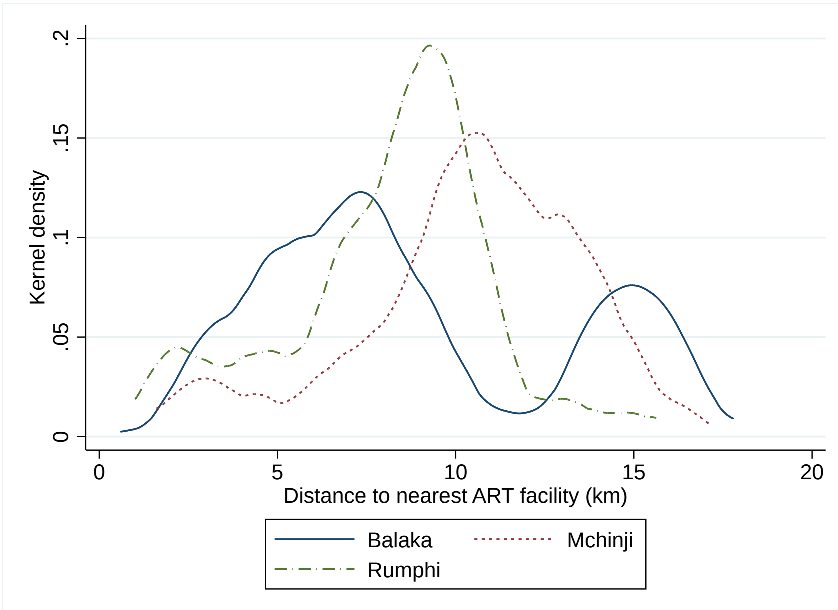

Figure E.1 – Distribution of distances to ART (in 2008) by region

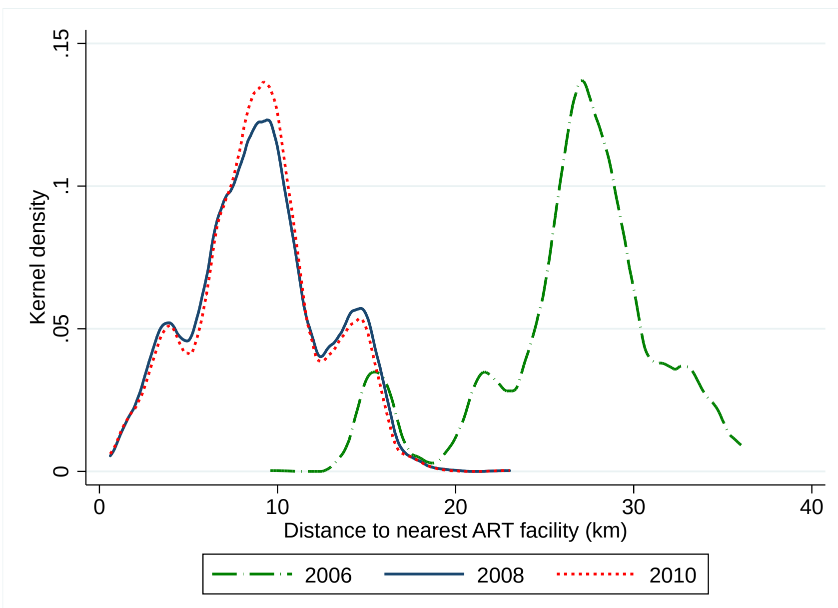

Figure E.2 – Distribution of distances to ART by year

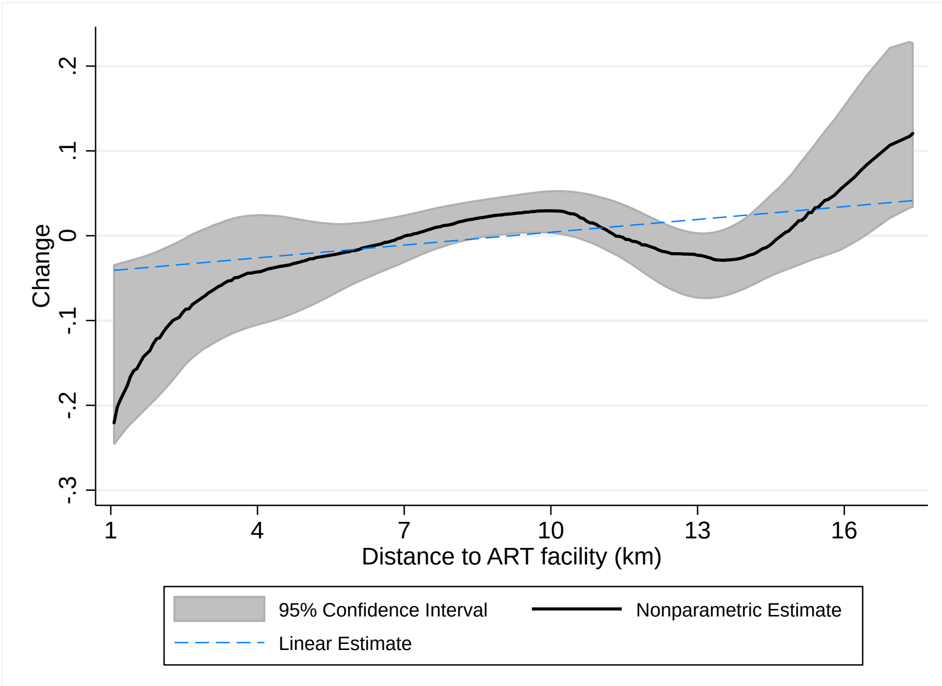

Figure E.3 – Effect of ART on 5-year subjective mortality risk by distance to ART

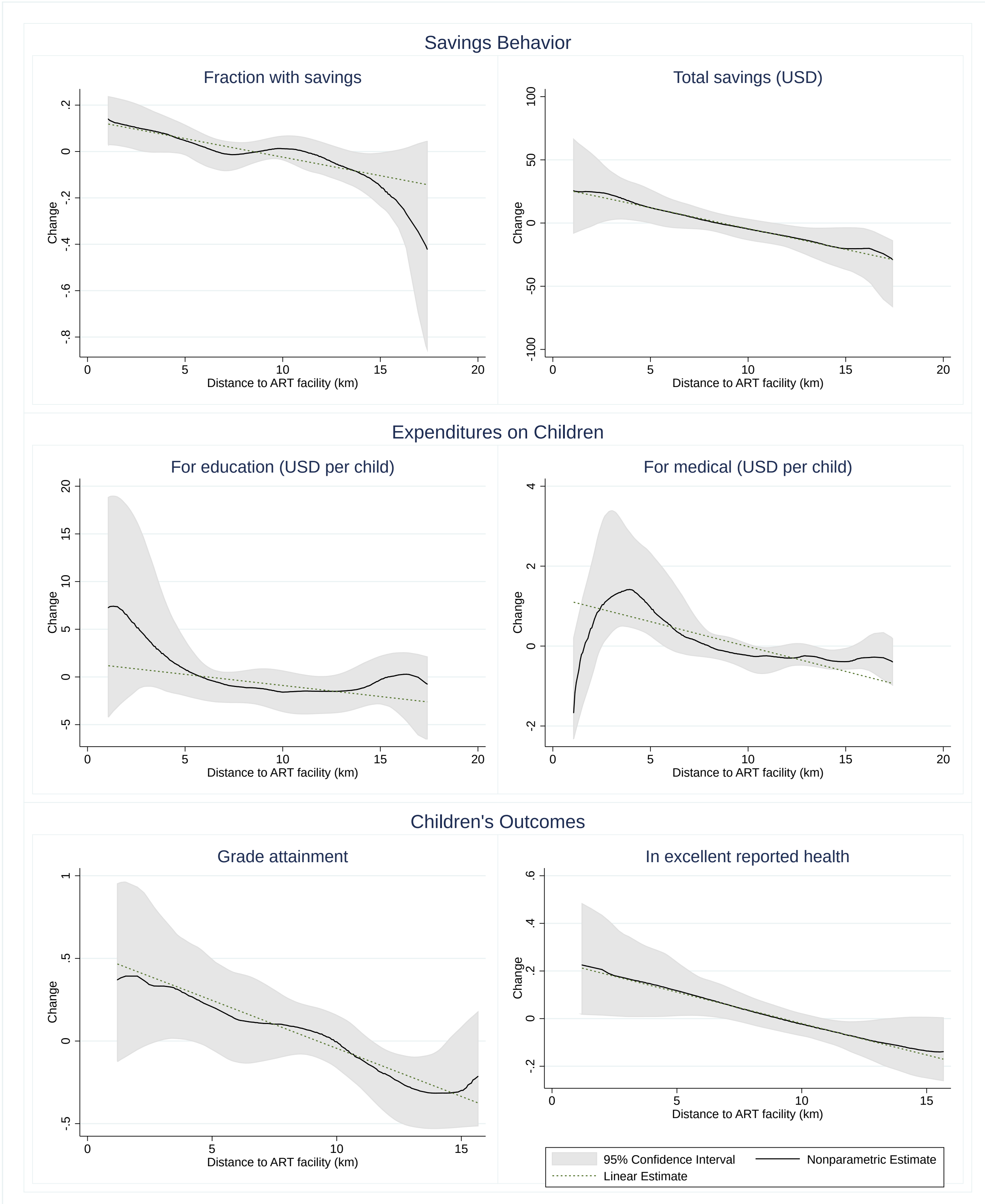

Figure E.4 – Effect of ART by distance

This figure shows nonparametric estimates of changes in the outcome variables by distance to ART. Changes are computed using 2010 as the "post" year, and 2006 and 2004 as the "pre" years (except savings and mortality risk, which do not have 2004 values). This corresponds to the coefficient on 2010 × *ART Proximity* in the parametric results presented in the tables. All graphs are nonparametric local linear regressions with region-year effects partialled out. Confidence bands at the 95% are computed using 1,000 bootstrap replications, clustered by village. In each bootstrap step, and undersmoothed local linear bandwidth is chosen following Hall (1992).

Table E.1 – Pre-characteristics for Attritors

	Sample	Attritors	Coefficient on ART Proximity:
	(1)	(2)	(3)
Panel A: Demographic Characteristics			
Age	36.85	33.74***	−2.15
Male respondent	0.41	0.49***	−0.04
Married	0.84	0.71***	−0.04
Household size	5.46	5.10***	−0.27
Education (grades completed)	5.10	5.49**	0.68**
Panel B: Economic Characteristics			
Labor income (USD)	80.58	90.71	−48.50
Wealth Index	0.11	0.15	0.59*
Land (hectares)	1.59	1.54	−0.22
High discount rate	0.66	0.64	0.01
Has metal roof	0.15	0.21***	0.02
Has bicycle	0.58	0.60	0.07
Has radio	0.76	0.74	0.03
Has mobile phone	0.04	0.05*	0.07**
Panel C: HIV, Health, and Risk Perceptions			
HIV positive	0.04	0.10***	0.06*
Perceived HIV risk	0.10	0.12**	0.03
Likelihood of HIV infection (Likert)	0.36	0.43**	0.13
Physical health score (PCS12)	52.50	52.18	−1.16
Mental health score (MCS12)	55.57	55.48	−1.56
Knows someone on ART	0.50	0.49	−0.15*
Worried about AIDS	0.27	0.30	0.03
Perceived mortality risk (5 year)	0.39	0.40	0.06*
Perceived prevalence (beans)	0.28	0.30	0.02
No. of relatives sick/died of AIDS	1.51	1.41	0.99***
Panel D: Savings and Expenditures on Children			
Has savings	0.22	0.24	0.06
Savings (USD)	17.14	26.37**	14.00
Education spending (USD/child)	1.38	2.28**	1.41
Medical spending (USD/child)	0.41	0.63**	0.12
Clothing spending (USD/child)	2.25	2.63	−0.87
Panel E: Spatial Characteristics			
Distance to ART in 2006 (km)	26.42	26.65	
Distance to ART in 2008 (km)	9.10	8.87	
Distance to clinic (km)	6.11	5.72*	
Distance to market (km)	5.29	5.51	
Distance to major road (km)	4.98	4.32***	
Distance to school (km)	1.66	1.67	
Population Density (pers/km^2)	100.68	103.91	
Sample size	1379	716	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Note: This table describes characteristics of respondents in 2006, before ART became available, for the sample of respondents in the analysis (column 1) and for those that were lost to followup (column 2). Stars in column 2 indicate significant differences with column 1. Column 3 provides the coefficient from regressing each the characteristic (in 2006) on ART proximity for the attritor sample (controlling for region and spatial characteristics) and stars indicate significant coefficients.

Table E.2 – Characteristics of Clinics by ART Start Date

ART Start Date:	Before 2005	2005-2006	2007-2008	2009-2010	No ART
	(1)	(2)	(3)	(4)	(5)
Catchment Population	43709	54092	30453	22605	18972
	(25872)	(46095)	(14320)	(13901)	(14131)
Number of Beds	312.5	120.4	14.9	13.1	11.7
	(286.5)	(102.3)	(13.0)	(14.3)	(27.2)
Electricity	1.0	0.9	0.5	0.5	0.4
	(0.0)	(0.2)	(0.5)	(0.5)	(0.5)
Flush Toilet	1.0	0.9	0.4	0.4	0.3
	(0.0)	(0.3)	(0.5)	(0.5)	(0.5)
HIV Testing	1.0	0.9	0.9	0.9	0.8
	(0.0)	(0.2)	(0.2)	(0.2)	(0.4)
Outpatient	1.0	1.0	1.0	1.0	1.0
	(0.0)	(0.1)	(0.0)	(0.0)	(0.2)
Inpatient Maternity	1.0	0.9	1.0	0.9	0.7
	(0.0)	(0.2)	(0.0)	(0.3)	(0.5)
Inpatient General	1.0	0.8	0.2	0.2	0.1
	(0.0)	(0.4)	(0.4)	(0.4)	(0.3)
Antenatal Clinic	1.0	1.0	1.0	1.0	0.8
	(0.0)	(0.1)	(0.0)	(0.2)	(0.4)
STI Clinic	0.9	0.8	0.5	0.5	0.3
	(0.3)	(0.4)	(0.5)	(0.5)	(0.5)
TB Clinic	0.9	0.9	0.8	0.7	0.7
	(0.2)	(0.3)	(0.4)	(0.4)	(0.5)
Laboratory	0.9	0.9	0.4	0.4	0.1
	(0.3)	(0.3)	(0.5)	(0.5)	(0.3)
Number of clinics	18	55	51	60	421

Note: This table shows a comparison of clinic characteristics according to the year they began providing ART. Column (1) shows the clinics that began providing ART before 2005, and most of these facilities had ART before the national rollout. Column (5) shows the characteristics for clinics that have not begun providing ART as of the beginning of 2011. Standard deviations of the means are in parentheses.

Table E.3 – ART Availability and Investment – Controls Interacted with Year

	Saving Behavior				Expenditures on Children					
	Any savings		Savings (USD)		Education (USD)		Medical (USD)		Clothing (USD)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2010 × ART Proximity	0.14***	0.11**	23.5*	18.9**	2.97*	2.01*	0.73***	0.61***	1.08	-0.32
	(0.048)	(0.049)	(13.2)	(7.46)	(1.73)	(1.07)	(0.27)	(0.22)	(0.87)	(0.65)
2008 × ART Proximity	0.12**	0.072	21.2**	14.1*	2.23*	0.014	0.54	0.39**	0.63	-0.22
	(0.051)	(0.048)	(9.38)	(8.29)	(1.34)	(0.86)	(0.36)	(0.17)	(1.17)	(0.79)
2010 × Clinic Proximity	-0.048		12.0		1.29		-0.027		-0.60	
	(0.032)		(15.4)		(1.65)		(0.18)		(0.92)	
2008 × Clinic Proximity	-0.023		-7.40		-2.34*		-0.083		-0.83	
	(0.046)		(5.91)		(1.41)		(0.18)		(0.66)	
Observations	3989	3125	3984	3123	2708	2506	2767	2564	2764	2562
Within R2	0.09	0.11	0.13	0.15	0.12	0.17	0.06	0.09	0.17	0.17
Spatial controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Shocks & aid programs	–	Yes	–	Yes	–	Yes	–	Yes	–	Yes
Demo. controls	–	Yes	–	Yes	–	Yes	–	Yes	–	Yes

* $p < .10$, ** $p < .05$, *** $p < .01$

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, region-by-year dummies, and month of interview controls. The sample is restricted to respondents with school-age children and regressions are weighted by inverse of number of household respondents. All spending regressions use data from 2004. Spatial controls include population density and proximity to clinic, market, major road and school (interacted with $Year_t$). Demographic controls include pre-period wealth, roof material, if the respondent has a mobile phone, age, household size, gender, education, and marital status (interacted with $Year_t$). Controls for economic shocks and other aid programs (also interacted with $Year_t$) are described in detail in the text.

Table E.4 – Effect of ART Availability on Savings Behavior - Robustness using HIV-neg. and Balanced Panel

Dependent variable:	Has savings			Savings (USD)		
	(1)	(2)	(3)	(4)	(5)	(6)
2010 × ART Proximity	0.23***	0.20***	0.19***	29.3**	26.0*	21.6
	(0.045)	(0.050)	(0.052)	(12.5)	(13.3)	(13.7)
2008 × ART Proximity	0.22***	0.20***	0.19***	23.2**	21.4*	17.0
	(0.058)	(0.061)	(0.064)	(11.4)	(11.9)	(11.6)
Spatial controls	Yes	Yes	Yes	Yes	Yes	Yes
Demographic controls	No	Yes	Yes	No	Yes	Yes
Econ shocks and aid program controls	No	No	Yes	No	No	Yes
Sample size	2257	2257	2257	2259	2259	2259
Within R^2	0.098	0.11	0.13	0.14	0.16	0.17

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, and region-year dummies. Spatial controls include population density and proximity to clinic, market, major road and school (interacted with post). Demographic controls include pre-period wealth, age, household size, gender, education, and marital status. Controls for economic shocks and other aid programs are described in detail in the text. The sample is restricted to individuals who are HIV-negative and excludes respondents who did not consent to testing. Additionally, the regressions are restricted to the fully balanced panel.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table E.5 – Effect of ART Availability on Expenditures on Children - Robustness using HIV-neg. and Balanced Panel

Dependent variable:	Education (USD)				Medical (USD)				Clothing (USD)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
2010 × ART Proximity	4.44*	3.52	4.25**	4.20**	0.93*	0.95*	1.13**	1.19**	0.99	0.51	0.16	0.38
	(2.39)	(2.11)	(2.01)	(1.94)	(0.55)	(0.54)	(0.55)	(0.54)	(1.01)	(1.11)	(0.96)	(1.04)
2008 × ART Proximity	-0.33	-1.55	-0.84	-0.90	-0.014	0.011	0.19	0.26*	-1.33	-1.90*	-2.24**	-2.03**
	(0.72)	(0.93)	(1.19)	(1.26)	(0.14)	(0.15)	(0.15)	(0.14)	(0.86)	(0.96)	(0.99)	(1.01)
2006 × ART Proximity				-0.28				0.24				0.81
				(0.99)				(0.19)				(0.80)
Spatial controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Econ shocks and aid program controls	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Sample size	744	744	744	744	880	880	880	880	876	876	876	876
Within R^2	0.13	0.15	0.16	0.15	0.058	0.062	0.064	0.063	0.15	0.16	0.19	0.19

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, region-year dummies, and month of interview controls. The sample is restricted to respondents with school-age children and regressions are weighted by inverse of number of household respondents. All regression use data from 2004. Regressions in columns (1), (5), and (9) are restricted to the balanced panel. Spatial controls include population density and proximity to clinic, market, major road and school (interacted with post). Demographic controls include pre-period wealth, age, household size, gender, education, and marital status. Controls for economic shocks and other aid programs are described in detail in the text. The sample is restricted to individuals who tested negative for HIV in 2008, and excludes individuals who did not consent to the test. The regressions are also done on a perfectly balanced panel, so that respondents have data for all relavent variables in all 4 years of the survey.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table E.6 – Effect of ART Availability on Schooling and Kids Health

Dependent variable:	Grades completed			In excellent health		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Full sample						
2010 × ART Proximity	0.26*	0.32*	0.34*	0.14**	0.13	0.11
	(0.13)	(0.18)	(0.18)	(0.06)	(0.08)	(0.08)
2008 × ART Proximity	0.06	0.13	0.12	0.12*	0.11	0.09
	(0.09)	(0.14)	(0.14)	(0.07)	(0.08)	(0.08)
Sample size	1578	1578	1524	1578	1578	1524
Within R^2	0.68	0.68	0.69	0.06	0.07	0.07
Panel B: Excluding HIV-positive						
2010 × ART Proximity	0.34***	0.39**	0.40**	0.15**	0.13	0.11
	(0.12)	(0.17)	(0.17)	(0.06)	(0.08)	(0.08)
2008 × ART Proximity	0.09	0.14	0.13	0.14**	0.11	0.09
	(0.09)	(0.14)	(0.14)	(0.06)	(0.08)	(0.08)
Sample size	1521	1521	1476	1521	1521	1476
Within R^2	0.69	0.69	0.69	0.07	0.08	0.08
Spatial controls	No	Yes	Yes	No	Yes	Yes
Demographic controls	No	No	Yes	No	No	Yes

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include child fixed effects, and region-year dummies. The sample is restricted to children who were reported in all three years of the survey (2006, 2008, and 2010). Regressions are weighted by inverse of number of children per household. Regressions in Panel B exclude children whose parents ever tested positive for HIV. * $p < .10$, ** $p < .05$, *** $p < .01$

Table E.7 – Effect of ART Availability on Schooling – DDD

Sample:	All Children			Exluding Children Age<12 by 2010		
	(1)	(2)	(3)	(4)	(5)	(6)
Girl × 2010 × ART Proximity	0.27	0.19	0.22	0.38*	0.30	0.33
	(0.21)	(0.21)	(0.20)	(0.22)	(0.22)	(0.21)
Girl × 2008 × ART Proximity	-0.03	-0.11	-0.10	0.00	-0.08	-0.08
	(0.15)	(0.16)	(0.15)	(0.16)	(0.17)	(0.16)
2010 × ART Proximity	0.24*	0.30	0.31*	0.25*	0.29	0.29
	(0.13)	(0.18)	(0.18)	(0.14)	(0.19)	(0.19)
2008 × ART Proximity	0.09	0.15	0.16	0.10	0.13	0.14
	(0.11)	(0.16)	(0.16)	(0.11)	(0.16)	(0.16)
Spatial controls	No	Yes	Yes	No	Yes	Yes
Demographic controls	No	No	Yes	No	No	Yes
Sample size	1521	1521	1476	1368	1368	1323
Within R2	0.69	0.69	0.70	0.69	0.70	0.70

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include child fixed effects, and region-year dummies. The sample is restricted to children who were reported in all three years of the survey (2006, 2008, and 2010). Regressions are weighted by inverse of number of children per household. Regressions exclude children whose parents ever tested positive for HIV. Columns (1)-(3) use the full sample of children aged 5-19, and Columns (4)-(6) only include children who were older than 12 years old by 2010. * $p < .10$, ** $p < .05$, *** $p < .01$